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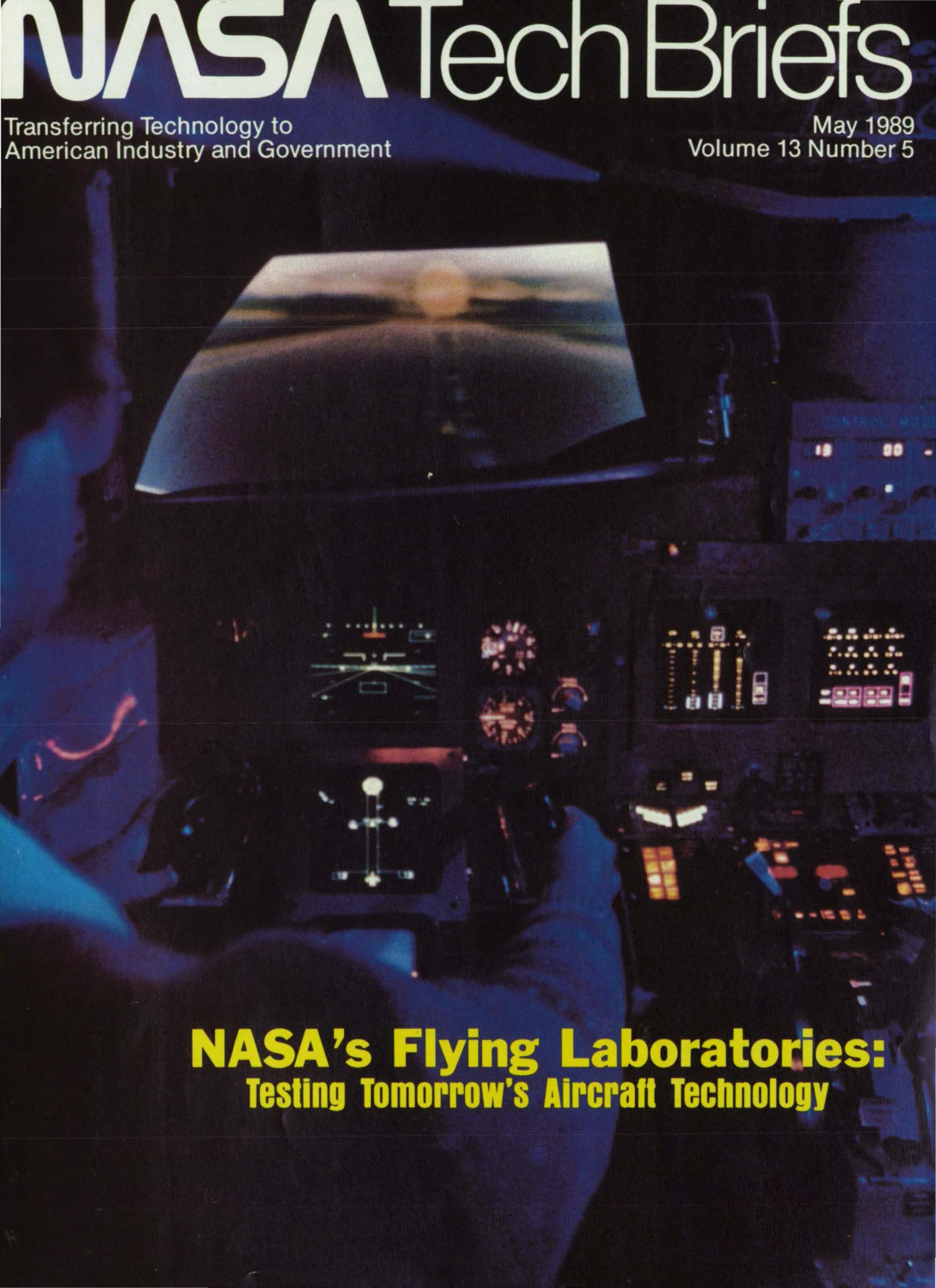
Volume 13 Number 5



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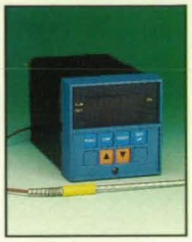

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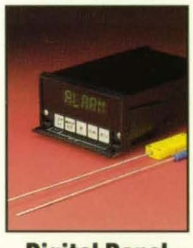

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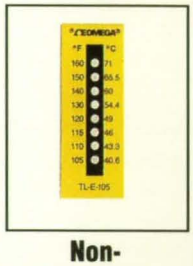

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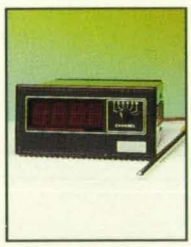

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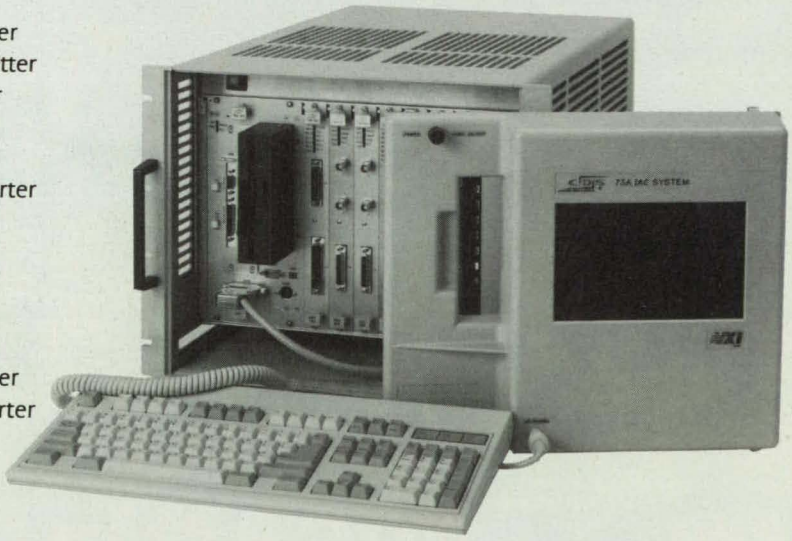

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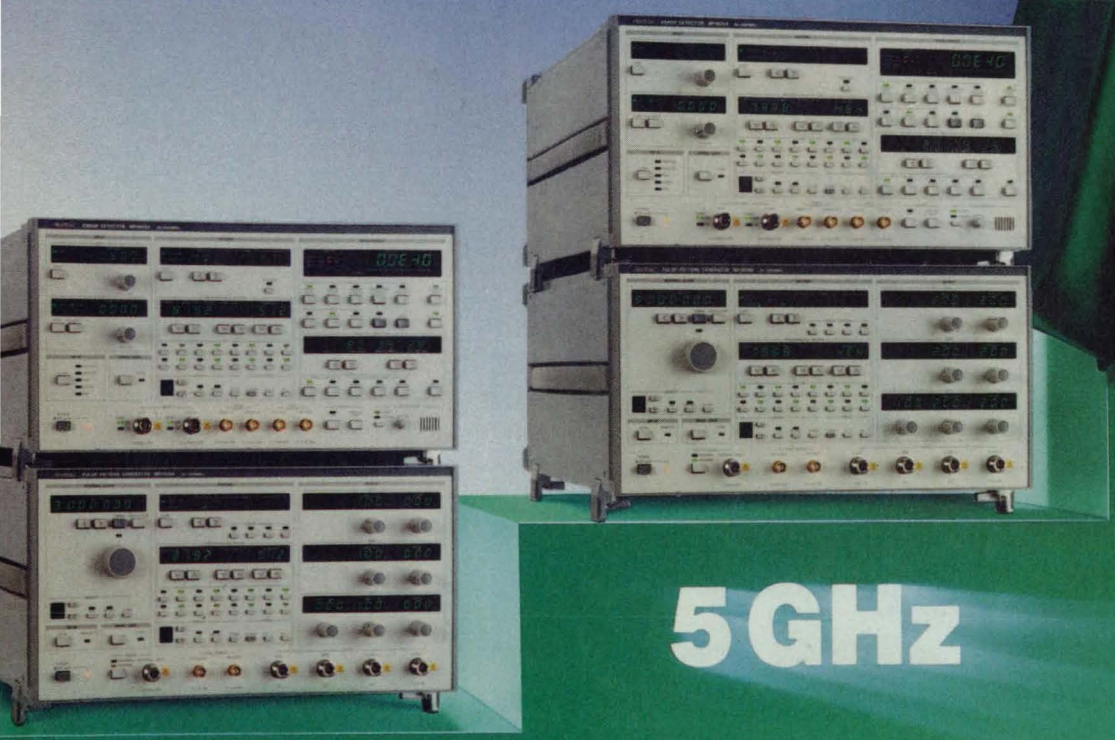

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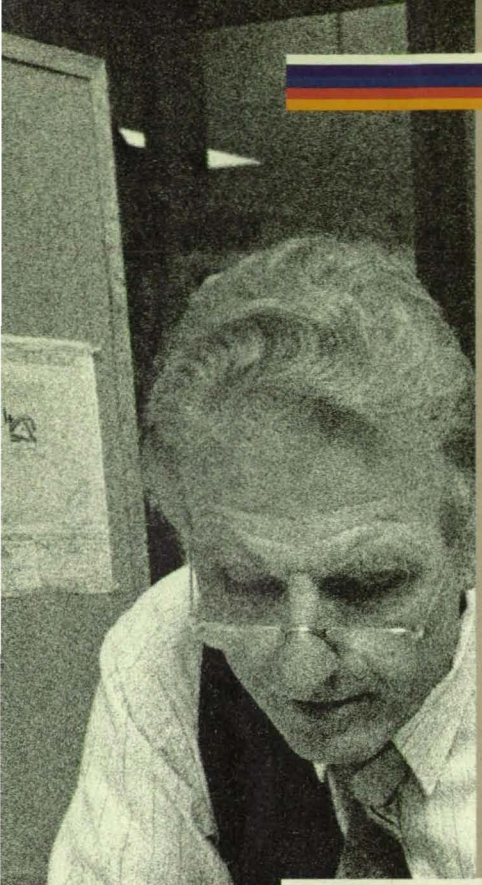

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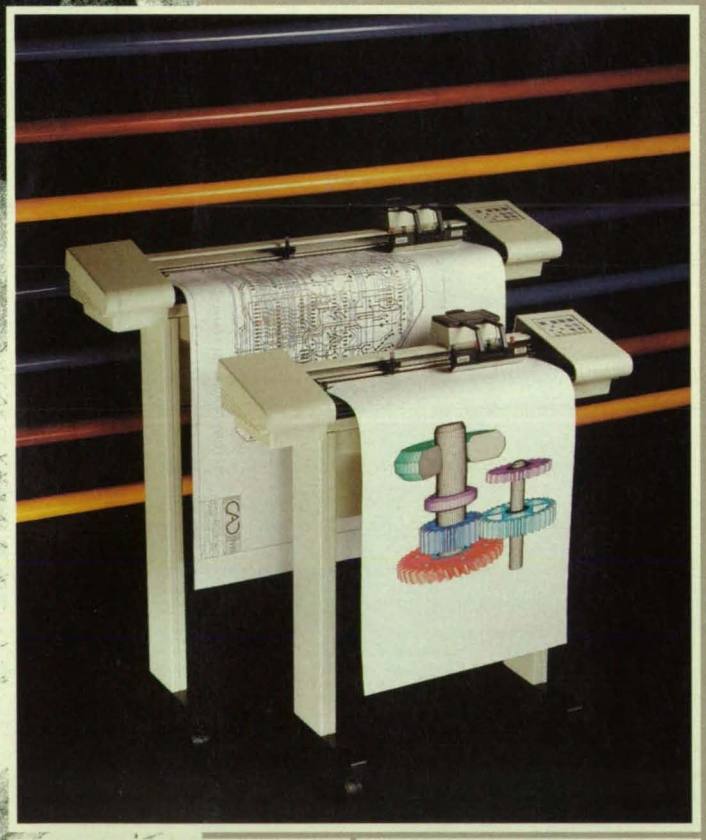

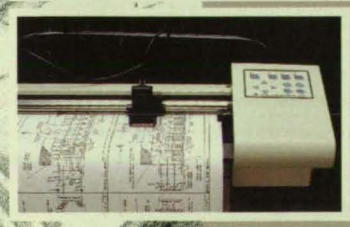

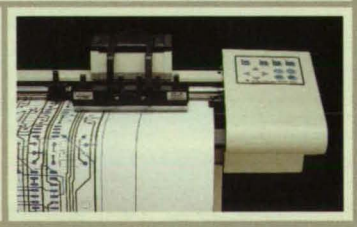

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SPECIAL FEATURES

TECHNICAL SECTION

The computer is making its way into the aircraft cockpit of the future. Along with other electronic advances, it is making possible a complete rethinking of what a cockpit should look like, how it should work, and how automation will assist tomorrow's pilots. See page 12.

DEPARTMENTS

On The Cover: New concepts for aircraft controls and displays are tested in NASA's Transport Systems Research Vehicle, a modified Boeing-737 with an all-electronic flight deck. Information displayed on the bottom screen (left of pilot's hand) and projected onto a simulated runway scene as a head-up display are part of a new invention called the Takeoff Performance Monitor System, which may one day help pilots take off and land more safely. Turn to page 12. *(Photo courtesy of NASA)*

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MOTOROLA

The Advanced Concepts Simulator serves as an engineering test bed for future transport and military aircraft crew systems.

Flight Station

(Photo courtesy the Lockheed-Georgia Company)

Computer advances are enabling a complete rethinking of what a cockpit should look like, how it should work, and how automation will assist pilots in the future.

The computer revolution has reached the aircraft cockpit. In coming years, pilots will use powerful expert systems and color-coded graphic displays to monitor a wide range of data, including flight path and speed, wind and weather conditions, traffic problems, and obstacles. The result, experts predict, will be smoother rides, fewer accidents, and improved on-time performance.

"Onboard computers can greatly aid the pilot in decision making," said George Sexton, a research engineer with the Lockheed-Georgia Company. "Properly applied, new control and display technology will provide precisely the information the pilot needs at the time it is needed."

To develop and test computer innovations for future flight, NASA and Lockheed-Georgia have built a cockpit simulator that represents a hypothetical 1995 transport aircraft. Called the Advanced Concepts Simulator (ACS), the highly modular cockpit has been incorporated into flight simulation facilities at NASA's Langley Research Center, Hampton, VA; Ames Research Center, Mountain View, CA; and Lockheed-Georgia, Marietta, GA.

The ACS provides full-mission simulation by placing pilots in a realistic environment, where they interface with the outside world, air traffic control, and all functional aircraft systems while performing typical (or atypical) flights. Its software architecture offers the flexibility to rapidly change the simulated aircraft systems, display formats, and flight conditions. "This makes the simulator a valuable tool for investigating a variety of issues within a short time period," stated Sexton.

Until recently, explained Samuel Morello of Langley's Flight Management Division, flight station designs have evolved through the introduction of improved or modernized instruments for individual systems. "New displays and controls have simply replaced outmoded units," he said. Now, however, computer advances offer new concepts in cockpit design, enabling safer and more efficient aircraft operations through an orderly flow of information controlled by the flight crew.

"Our objective," Morello said, "is to heighten the pilot's situation awareness by improving the availability of information and ease of interpretation, which can reduce the possibility of missed signals or misread data."

A Sleek New Design

The simulator's unique desktop design resembles an office or laboratory workstation. A row of five cathode ray tubes, aligned left-to-right at the rear of a nearly flat control surface, are programmable so that flight data can be displayed in a logical, easy-to-see format. The outside screens provide navigation and flight information, while the center three screens show engine and systems status, weather conditions, surrounding air traffic, and functional systems such as fuel—all controlled by touch panel overlays. Lockheed's simulator also features two holographic head-up displays which present primary flight data, allowing the crew to simultaneously see the symbology and look outside the aircraft. This could improve safety on low visibility approaches by enabling the pilot to focus on the runway more quickly than with a transition from

Of The Future

head-down to head-up flying.

Fly-by-wire/light flight and thrust control systems permit traditional columns and wheels to be replaced by less bulky side-stick controllers. Essentially a joystick connected to the simulator's VAX 8800 host computer, the side-stick controller creates a roomier cockpit and increases the flight crew's field of vision.

Experimenters use realistic communications, including voice disguisers, to provide air traffic control (ATC) to the test plane and other pseudo aircraft operating in the same "airspace." Designed for NASA by the Massachusetts Institute of Technology, the ATC simulator features two independent controller stations that can be reconfigured from one geographical area to another in less than a minute, allowing the control position to "leapfrog" in order to follow the plane's progress. Lockheed-Georgia plans to modify the ATC simulator to include military command and control systems, such as the Joint Tactical Information Distribution System, when the advanced cockpit is used to test future military crew systems.

Computer-generated color scenes appear outside the cockpit windows, adding to the illusion of flight. Created by Link-Miles' Image II visual system, the scenes depict specific airports and their surroundings as viewed at night. Special effects include adjustable cloud heights, ground fog, runway markings, and ground and airborne traffic.

Many system-monitoring functions are performed automatically in the ACS. A prime example is the Advisory, Caution, and Warning System, which aids the flight crew in fault detection and analysis. Other unique design features are: automatic loading of navigation data into the computer system; a four-dimensional navigation system; tailored logic for operations based on artificial intelligence; and data-linking of traffic and weather information from "ground-based" computers to the cockpit.

Through Rain, Sleet, or Snow

Langley researchers plan to use the ACS to study the application of advanced controls and displays for all-weather flying. Explained George Steinmetz, Head of Langley's Vehicle Operations Research Branch: "The pilot of the future may be enroute, with a nice preprogrammed route already stored in the computer, when a thunderstorm drifts across the flight path. We want it to be very convenient for the pilot to change the airplane's course, skirt the storm, and get back on schedule.

"One possibility is to have the pilot touch his map display (on one of the video screens) and say, 'I want a new way point there and there,' and have the computer do most of the work. It would find the new course and compute the new bearings, and would even increase the plane's speed just the right amount to compensate for traveling the extra distance, so the flight could stay on schedule."

In Steinmetz's example, the pilot used a voice recognition system—another new invention the ACS will test—to communicate with the computer. Voice systems can extend the flight crew's control through speech when their hands are busy with other tasks.

One of the first experiments conducted in the Langley simulator was a comparison between voice input and manually keying entries on a telephone-like pad for radio communications. Researchers believe that voice input, to be efficient, must take on an advanced, "intelligent" form. "The one-for-one replacement of spoken words for finger actions is not a good use of voice input," said Steinmetz. "But if a pilot could select radio frequencies, for example, by simply saying 'Denver tower' and the system is smart enough to understand those words and perform the rest of the task, then that's a different ball game."

This close-up look at one of the ACS displays reveals a logical, easy-to-use format. The top portion provides information about airplane attitude, flight path, airspeed, and altitude, while the bottom part shows the pilot his navigational position relative to ground-based radio aids and natural landmarks. (Photo courtesy NASA)

Intelligent Tools

At NASA Ames, reseachers are employing the ACS to examine a variety of intelligent crew systems, including "Smart Checklists" that appear on the desktop display during each phase of flight to assure the pilot has completed required tasks. The pilot checks off items by touching the appropriate line on the video screen. A "checklist incomplete" message reminds the pilot of skipped items, and also serves as a touch panel switch to recall a missed step. When an item associated with a functional system reaches the top line of the checklist, a schematic of that system automatically appears so that its controls can be operated through the touch panel.

Another Ames effort will evaluate a Traffic and Collision Avoidance System that could be installed on transport aircraft as early as 1991. Transponders gauge the position of other aircraft and feed that data into the onboard computer, which applies a complex algorithm to determine whether another plane is too close for comfort. If the computer detects a potential collision, alarms sound and the pilot is instructed—via computerized voice synthesis—to climb, dive, or perform other maneuvers to escape the danger.

The Human Factor

Both NASA simulators support extensive human factors research, exploring the human side of the people-machine relationship. For example, scientists want to know if, after long hours in what is essentially a video cockpit, the crew will experience more or less fatigue compared with a standard flight station. This work involves taking brainwave measurements during simulated flights to determine the pilot's interest level.

"We have to be careful not to overautomate the cockpit," said John Garren, Chief of Langley's Flight Management Division. "It's important we maintain the proper level of cockpit workload, keeping the pilot involved and alert to avoid complacency."

The ultimate goal of NASA's simulator research is to transfer the existing technology to American industry and have it incorporated in the next generation of commercial aircraft.

"We foresee the computer becoming an electronic crew member on future flights," Garren said. "If there's a time-critical problem, the pilot will have an expert at his fingertips who can instantly come up with a solution."

(Photo courtesy NASA)

NASA's Transport Systems Research Vehicle features an all-electronic flight deck.

The Flying Laboratory

The idea of totally redesigning the transport flight station is largely an outgrowth of another NASA research project that introduced electronic cathode ray tubes to the cockpit of a specially instrumented Boeing-737 jetliner. This flying laboratory, dubbed the Transport Systems Research Vehicle (TSRV), is operated by the Langley Center as part of a cooperative effort with the Federal Aviation Administration to explore technology for safer and more efficient air travel.

The TSRV features two flight decks: a conventional forward deck and a fully operational research flight deck, located in the main cabin aft of the standard pilot's compartment. From the windowless aft cockpit, research crews fly the airplane using computer-driven systems and color displays, while pilots on the standard deck monitor the flight.

In addition to navigation and flight displays in front of both pilot and copilot, center panel video screens provide the capability to monitor engine and systems status and to manage aircraft systems operation, which should result in reduced crew workload. The center screens allow experimenters to examine how additional data can be displayed to improve air traffic control (ATC) communications, flight management options, and traffic awareness.

Langley recently used the TSRV to test a breakthrough invention called the Takeoff Performance Monitor System. Onboard computers predict when and at what speed the airplane will take off. If takeoff performance is less than satisfactory, a warning is sounded to the pilot. This system is designed to prevent the type of accident that occurred in Washington, DC in 1982 when a commercial jet did not have enough power to take off and crashed in the Potomac River.

Next year, the TSRV will be fitted with a ring around its fuselage—a small airfoil standing several inches from the surface—that reduces turbulent drag. This basic aerodynamic concept for improving fuel economy will be tested in flight for the first time on the modified Boeing-737.

Other scheduled experiments include the study of various onboard sensors for the detection of wind shear and the evaluation of aircraft-ATC technology integration for improved traffic flow near airports. Furthermore, NASA and McDonnell Douglas plan to test a helmet-mounted display that could be used by pilots in windowless aircraft or other applications where the pilot cannot see outside the cockpit. □

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See NASA Tech Briefs for technical details, 1986, 1987 and 1988.
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New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 18). NASA's patent-licensing program to encourage commercial development is described on page 18.

Laser-Assisted Growth of AlGaAs Films

Films of aluminum gallium arsenide can be grown on gallium arsenide by laser-assisted organometallic chemical-vapor deposition. The films are single-crystal and contain no detectable oxygen or carbon. (See page 83).

Optical Addressing and Clocking of RAM's

A proposed random-access-memory addressing system, in which the memory is linked optically to the read/write logic circuits, would greatly increase computer operating speed. The system could be applied to high-capacity digital systems, supercomputers, and complex microcircuits. (See page 32).

Programmable Positioner for Spot Welding

The present method of manufacture of large missile tanks has required tedious resistance welding of thousands of spot welds. Welds are now spaced and performed in sequence automatically by economical automated welding station that has produced significant improvements in productivity and in quality. (See page 82).

Graphite Fluoride Fiber Composites for Heat Sinking

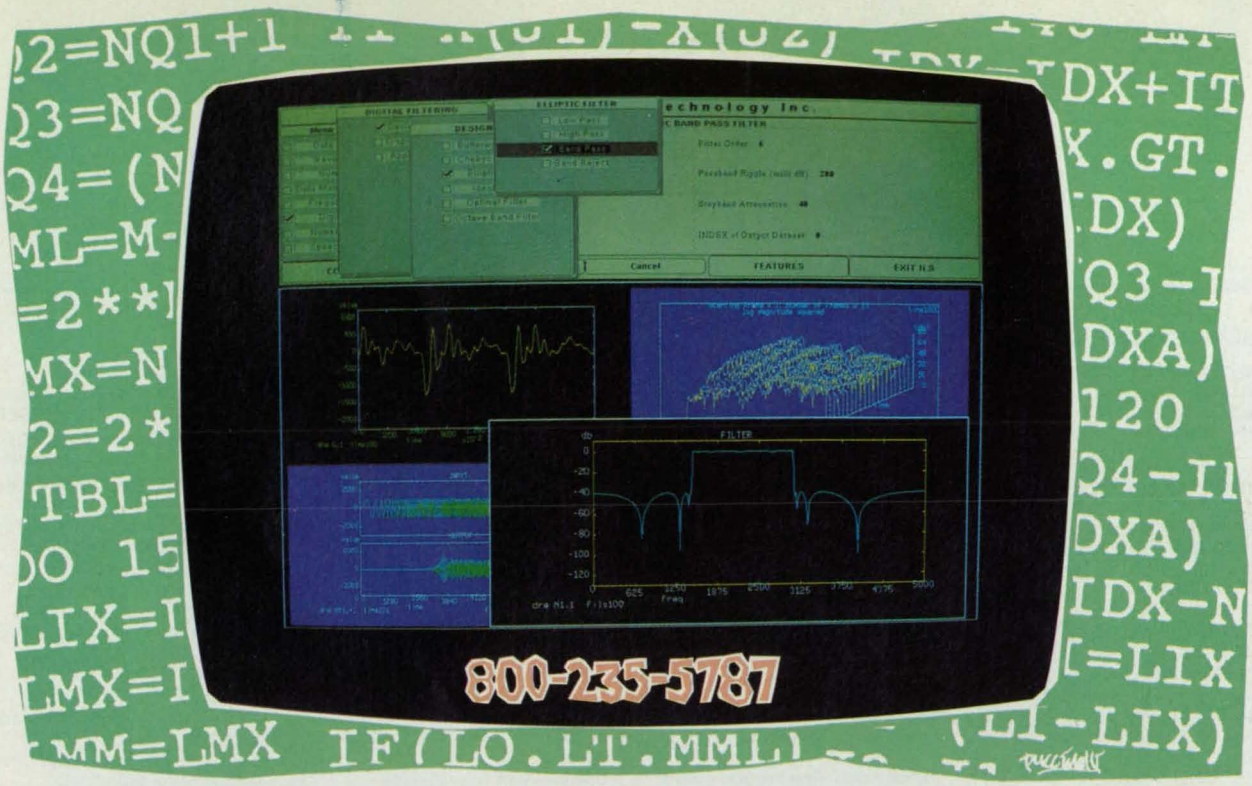
Graphite fluoride fiber/polymer composite materials consist of graphite fluoride fibers in epoxy, polytetrafluoroethylene, or polyimide resin. They combine high electrical resistivity with high thermal conductivity and thus may solve the heat-transfer problems of many electrical systems. (See page 54).

Optical Tracker for Longwall Coal Shearer

A tracking system records the lateral movements of a longwall coal-shearing vehicle. The system detects the lateral and vertical deviations of the path of the vehicle as it moves along a coal face, shearing coal as it goes. (See page 74).

Plasma/Neutral-Beam Etching Apparatus

An apparatus has been developed to produce intense beams of reactant atoms for simulating oxygen erosion, for studying beam-gas collisions, and for etching semiconductor substrates. A plasma is ejected from a coaxial plasma gun toward a neutralizing plate, where it is turned into a beam of atoms or molecules and aimed at a substrate to be etched. (See page 83).



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If you need further information about new technologies presented in *NASA Tech Briefs,* request the Technical Support Package (TSP). If a TSP is not available, you can contact the Technology Utilization Officer at the NASA Field Center that sponsored the research. He can arrange for assistance in applying the technology by putting you in touch with the people who developed it. If you want information about the patent status of a technology or are interested in licensing a NASA invention, contact the Patent Counsel at the NASA Field Center that sponsored the research. Refer to the NASA reference number at the end of the Tech Brief.

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Thermoplastic Composites... The Time Is Now.

Savings from the Start

TPC offers commingled yarns and thermoplastic powder prepregs specifically designed to reduce composite materials and fabrication costs. Our prepregs offer cost advantages when compared with currently available thermoplastic matrix systems. Available in rovings, unidirectional tapes and fabrics, TPC products can revolutionize the way you fabricate composite parts while delivering even greater performance.

Productivity Plus Performance

Thermoplastic composite materials offer cost performance advantages over more conventional thermoset materials. The primary cost advantage is due to reduced processing costs.

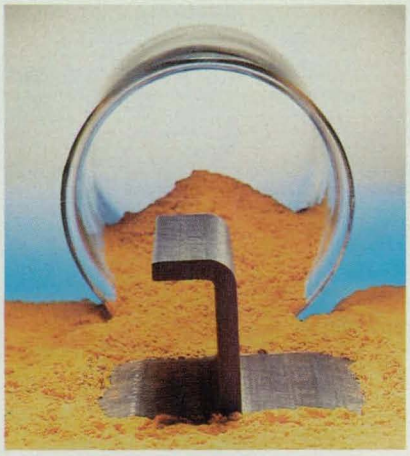
Thermoplastic composites:

- Do not require cold storage
- Require relatively short process cycles
- Produce less scrap because of their ability to be reprocessed.

Performance advantages, characterized by the finished product include:

- Longer life cycle
- Greater durability
- Repairability

Until now, thermoplastic composite materials have posed significant manufacturing challenges due to the nature of the available prepreg forms. Typically, these prepregs are either "stiff and boardy"



We are currently defining the processing parameters for:

- Compression molding
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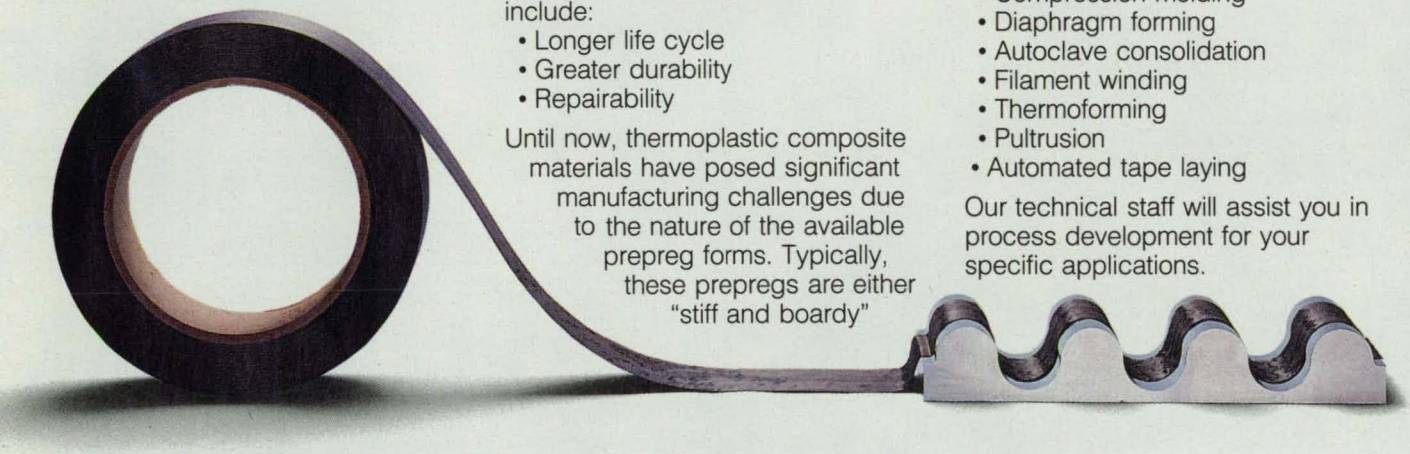
- Autoclave consolidation
- Filament winding
- Thermoforming
- Pultrusion
- Automated tape laying

Our technical staff will assist you in process development for your specific applications.



Prepregs, Yarns and Powders

TPC thermoplastic prepregs are available in two distinct forms; comingled yarns and powder prepregs. Available forms include rovings, unidirectional tapes and fabrics.

TPC comingled yarns are a precise mix of a structural fiber and filamentary polymer. This material form offers drape and precise control over fiber volume content.

TPC's proprietary powder technology provides thermoplastic preforms which possess both drape and tack without the presence of solvents. or contain solvents which complicate the processibility of the materials. Our unique forms of thermoplastic composite prepregs offer drapability and tack (in the case of our powder prepregs) allowing complex contoured shapes to be processed with greater ease.

Processing Simplified

Fabrication of complex parts utilizing TPC's flexible rovings, unidirectional tapes and fabrics is much simplier than stiff thermoplastic prepreg systems.

Act Now

For an immediate response write or call: Steve Clemans

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Proprietary materials development. Our mesophase pitch fibers, based on unique technology patented worldwide, are now available in more forms than ever, including individual prepreg plies of one mil thickness. These materials and materials systems demonstrate properties essential for solving many of your most demanding problems when it comes to aero, outer and deep space applications.

New performance frontiers. So far, this new technology has shown stiffness characteristics far superior to current materials. It also imparts unsurpassed dimensional stability allowing you to tailor coefficients of expansion to 0 or negative if required. Plus, with thermal conductivity 3 to 5 times that of copper, it can solve many of the thermal management problems encountered in aerospace designs.

The attainable unknown. While current applications include laser hardening, low observable technology and use in space radiators, space panels and heat sinks, the potential of this material can take you far beyond today's design limits. With our ongoing research and the evolution of design the mysteries of space will, in time, be revealed.

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Electronic Components and Circuits

Composite Semiconductor Substrates

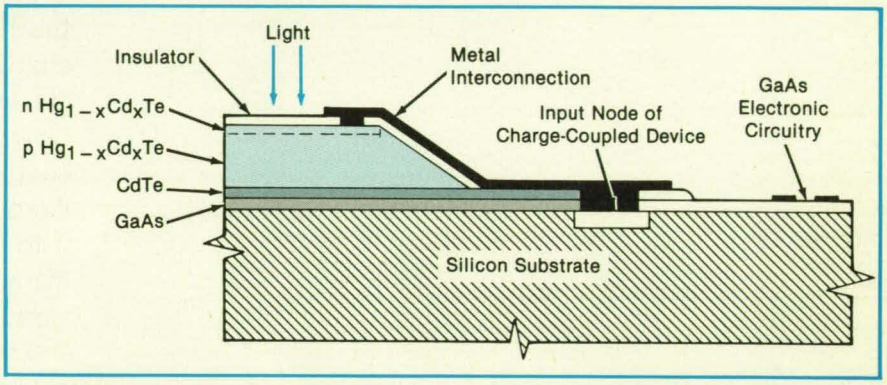
Layered structures pave the way for monolithic imaging devices. B89-10211

NASA's Jet Propulsion Laboratory, Pasadena, California

An epitaxial structure of three semiconductor materials — silicon, gallium arsenide, and cadmium telluride — may make possible integrated monolithic focal-plane arrays of photodetectors. The silicon layer would contain charge-coupled devices, the gallium arsenide layer would contain other fast electronic circuitry, and the cadmium telluride layer would serve as the base for an array of mercury cadmium telluride infrared sensors (see figure).

Currently, focal-plane arrays are made by hybrid technology. The various semiconductor components are bonded to substrates and interconnected. For example, an HgCdTe array of photodiodes can be stacked on a silicon array of charge-coupled devices by joining the two arrays via indium contact bumps. A monolithic array would be more reliable and manufacturable and could contain smaller, more closely spaced elements for higher resolution of the image.

The present work describes how CdTe was grown on GaAs/Si substrates. Both the <100> and <111> orientations of the substrates were used. This new growth technique effectively combines two well-established techniques; namely, metalorganic chemical-vapor deposition (MOCVD) and molecular-beam epitaxy (MBE). CdTe is grown via MOCVD, which results in a highly-efficient throughput, low-cost production of this material. GaAs is initially grown on Si by MBE, a process featuring very precise nucleation for obtaining device-quality GaAs on Si.



A **Multilayer Structure** would include HgCdTe light sensors with Si readout devices and GaAs signal-processing circuits. A CdTe layer would provide a base for building up the HgCdTe layer.

An initial degreasing of the Si wafers is followed by a series of oxidation and oxide-removal steps. Oxide-covered Si wafers are then spin-etched to remove the oxide inside a nitrogen glove box and then transferred by load-lock into the MBE-growth chamber. A slow growth of GaAs at the rate of 0.1 monolayer/s at 400 °C is followed by faster growth at 1 μm/h at 580 °C.

In the MOCVD process, CdTe epilayers having very specular mirrorlike surfaces are grown on the above MBE-grown samples of GaAs/Si. Growth is conducted at atmospheric pressure in a horizontal quartz reactor with an RF-heated graphite susceptor. The metalorganics are transported into the reactor by palladium-purified hydrogen, and preliminary runs are conducted at 400 °C.

This work was done by Akbar Nouhi, Gouri Radhakrishnan, Joseph Katz, and Kris Koliwad of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 45 on the TSP Request Card.*
NPO-17342

Computing Resonances of Waveguide-to-Microstrip Transitions

Trial-and-error design procedures are no longer necessary. B89-10212

Lewis Research Center, Cleveland, Ohio

A simplified mathematical model can be used to predict the resonant frequencies of antipodal-finline waveguide-to-microstrip transitions. There is an increasing need for such transitions and the mathematical tools to design them because the trend in microwave integrated circuits is to use microstrip connections, but low-loss transmission lines and test equipment for millimeter wavelengths require rectangular waveguides.

Previous design rules did not address directly the resonant frequencies of transitions, which had to be found by trial and error and which must be placed outside the frequency bands of the devices to which they are connected. The new model makes it possible to place the undesired resonances outside the desired frequency band during the design process; this will eliminate much of the iteration in the design process and thereby reduce both the time and the cost of design.

In region I of the transition (see Figure 1), the tapered antipodal finline concentrates the electric field and rotates it 90° from the incident TE_{10} waveguide mode to the quasi-microstrip mode. The high impedance of the TE_{10} waveguide mode is transformed to a lower impedance — usually about 50

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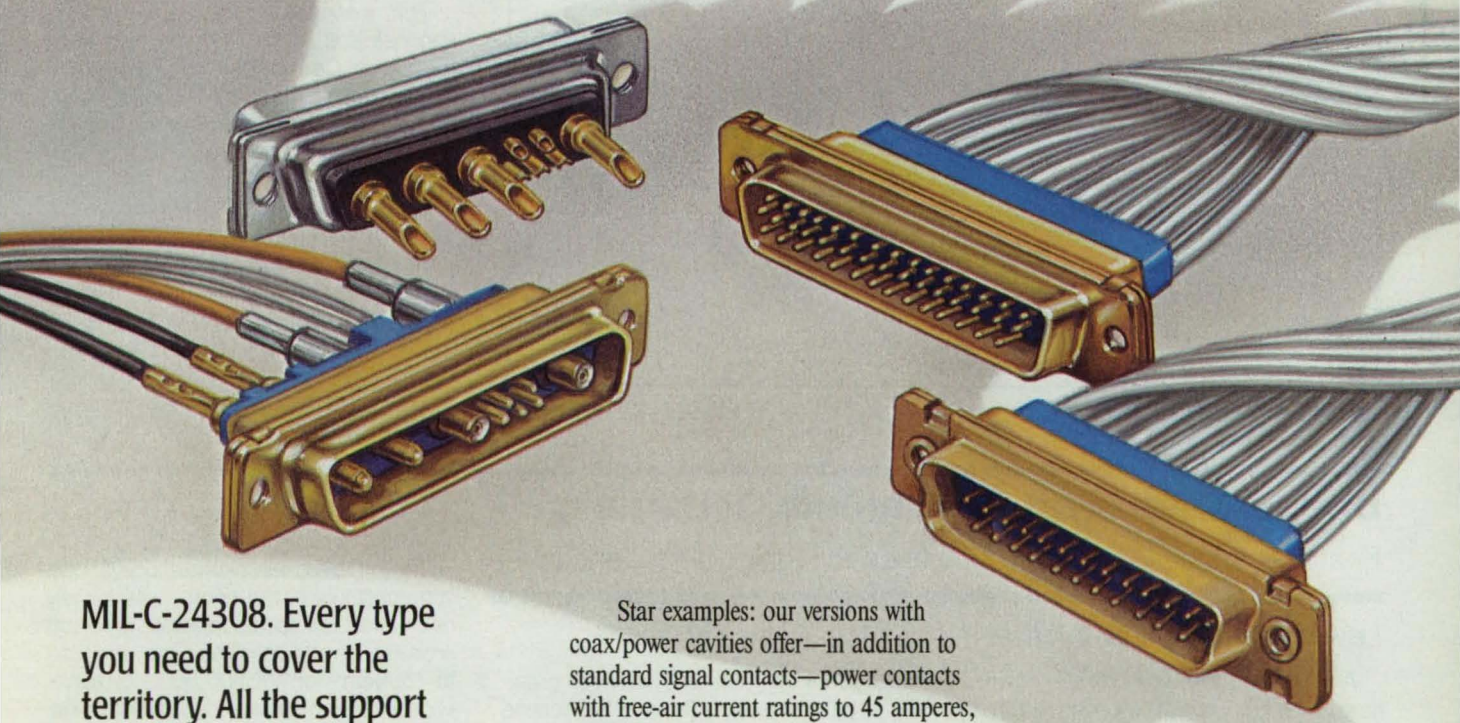

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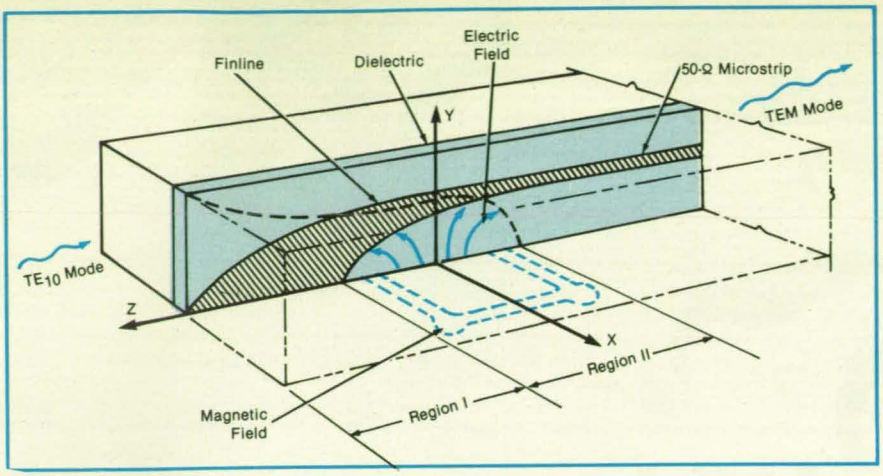

Figure 1. An **Antipodal-Finline Waveguide-to-Microstrip Transition** transforms the incoming high-impedance TE_{10} waveguide electromagnetic mode to the low-impedance outgoing stripline mode.

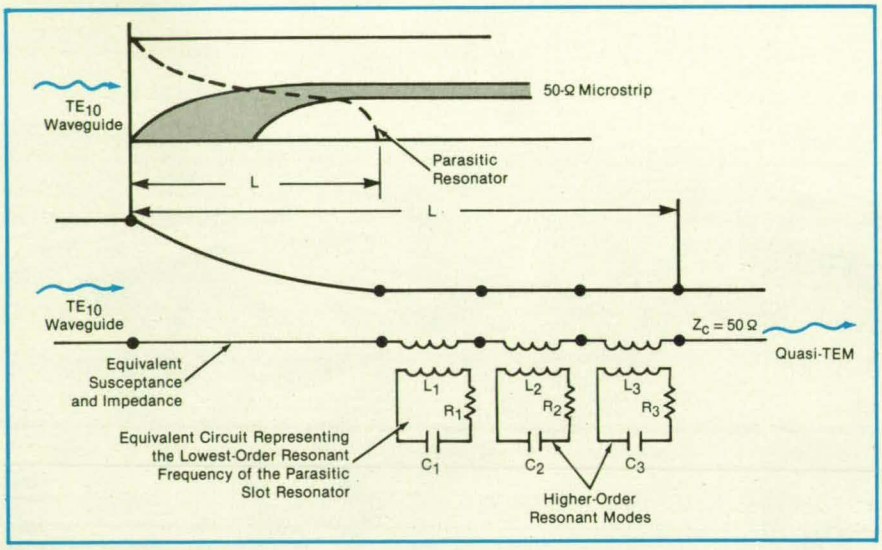

Figure 2. This **Lumped-Element Model** gives good approximations for the resonances of the waveguide-to-microstrip transition.

Ω — typical of microstrip transmission lines. In region II the transformation continues from the finline to the stripline mode. The waveguide-to-finline interface and the discontinuities of the finline create evanescent modes in region II that give rise to the resonances.

The model is based on diagrams of the electromagnetic field and on experimentally derived parameters. A tapered transmission line is considered to be in series with an infinite set of coupled resonant circuits (see Figure 2). Each resonant circuit is treated as a resonance of a microwave resonant cavity, of which the resonant frequencies can be determined easily.

The success of the model depends on the choice of a model cavity and an effective permittivity that makes the resonances of the cavity coincide with the experimental values. In many practical cases, the need is met by a model of a cylindrical cavity filled with a material, the permittivity of which depends on the length of region II but is nearly independent of the frequency.

This work was done by George E. Ponchak and Alan N. Downey of **Lewis Research Center**. *Further information may be found in NASA TM-88905 [N87-16958/NSP], "A New Model for Broadband Waveguide to Microstrip Transition Design."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LEW-14637

Barium-Dispenser Thermionic Cathode

B89-10213

Features include long operating life and high current density.

Lewis Research Center, Cleveland, Ohio

An improved reservoir cathode serves as an intense source of electrons required for high-frequency and often high-output-power, linear-beam tubes, for which long operating lifetime is an important consideration. The continuing development of millimeter-wave tubes capable of powers of hundreds to thousands of watts for applications in space communications and in high-resolution radar systems has created a large and growing demand for thermionic cathodes capable of fully-space-charge-limited (FSCL) emission-current densities of 4 A/cm^2 or more.

These high current densities are needed for higher beam currents, smaller beam sizes, and better focusing of beams, and because of practical limitations on the convergence of beams in electron guns. Gridded gun structures demand the capability for current densities that are even greater — by as much as a factor of 2. Because of the very high costs of high-performance tubes and the systems in which they operate, long-life operation and reliability of cathodes are obviously of great importance.

Barium-dispenser thermionic cathodes, in particular the Ba-impregnated type, are most commonly used in tubes for space-communication and radar applications. Barium is essential to reduce the work functions of the emitting surfaces sufficiently for useful levels of thermionic emission at temperatures of the order of 1,000 °C. During the operation of a cathode, Ba is continuously lost through evaporation and must be replenished to maintain high emission. The lifetime of a cathode is thus critically dependent upon the availability of Ba.

The improved reservoir cathode, shown schematically in the figure, was initially developed for continuous operation at emission-current densities in the range of 4 to 10 A/cm^2 for 100,000 hours or more. High emission-current densities are obtained through the use of an emitting surface of relatively-low effective work function and narrow work-function distribution, consisting of a coat of W/Os deposited by sputtering. Lower operating temperatures and enhanced electron emission are consequently possible.

In addition, a segregated-grain-size W powder is used for the porous Ba-vapor-diffuser plug to control the flow and allow adequate amounts of Ba to reach the surface with no need for cathode temperatures higher than required for the desired level of emission current. Long operating life is achieved by using a reservoir of BaO to store the Ba. The advantage of this approach is a constant rate of supply of Ba until practically the entire amount of Ba in

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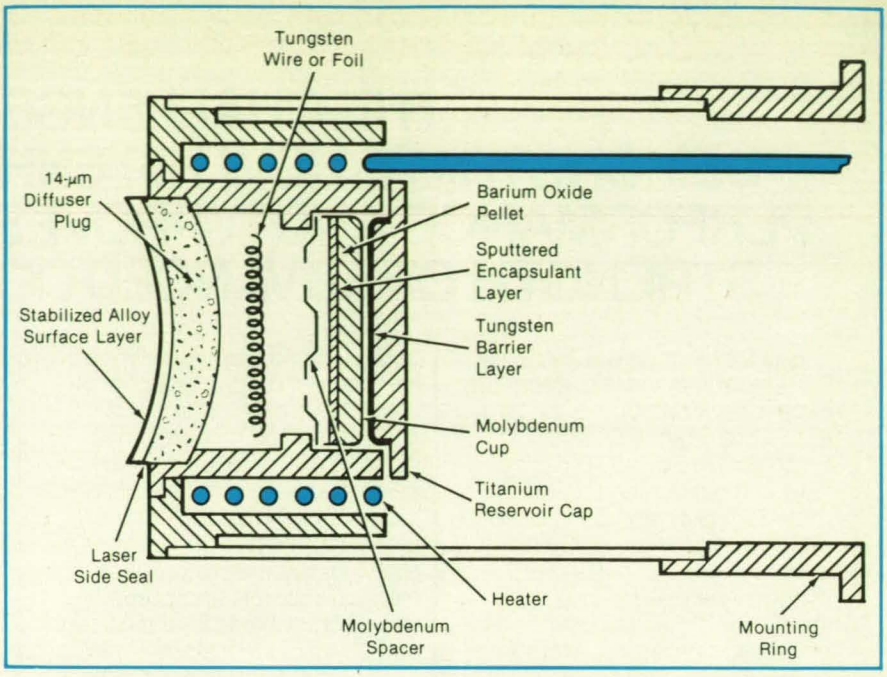
the reservoir, which can be quite large, is exhausted. Also contributing to longer life is the stabilization of the W/Os composition of the emitting surface by means of a W/Os diffusion barrier formed in the underlying W matrix by an Os-chemical-infiltration technique.

In emission tests of the improved reservoir cathode, FSCL current densities of as much as 16 A/cm^2 have been obtained. The W/Os alloy surface has been demonstrated to be capable of more than 50 A/cm^2. Although originally developed to span a smaller range, the effective range of current densities for the cathode is 1 to 50 A/cm^2 and possibly as high as 100 A/cm^2. It is possible to store enough Ba (about 0.5 g) in the reservoir to endure about 100,000 hours of operation at this current density or less time at greater current densities.

This work was done by Edwin G. Wintucky of **Lewis Research Center** *and M. Green and M. Feinleib of Varian Associates, Inc. No further documentation is available.*
LEW-14685



The **Improved Reservoir Cathode** stores Ba in the form of BaO to replenish the Ba lost from the emitting surface. (The Ba lowers the electron work function to enhance thermionic emission.)

Metal Coat Increases Output Sensitivity

B89-10214

Quantum efficiency, charge-collection efficiency, and low read noise are optimized.

NASA's Jet Propulsion Laboratory, Pasadena, California

A charge-coupled photodetector (see Figure 1) has been optimized for maximum quantum efficiency (QE), high charge-collection efficiency, and ultralow read noise. Called a "flash-coupled" photodetector, the sensor delivers high quantum-efficiency sensitivity in the spectral range extending from the soft x ray to the near infrared (1 to 11,000 Å.

The detector incorporates a "flashgate," which is a sparse (less than a monolayer) surface deposit of metal that has a high work function relative to the substrate of the sensor. The flashgate creates an electric field greater than 10^5 V/cm that

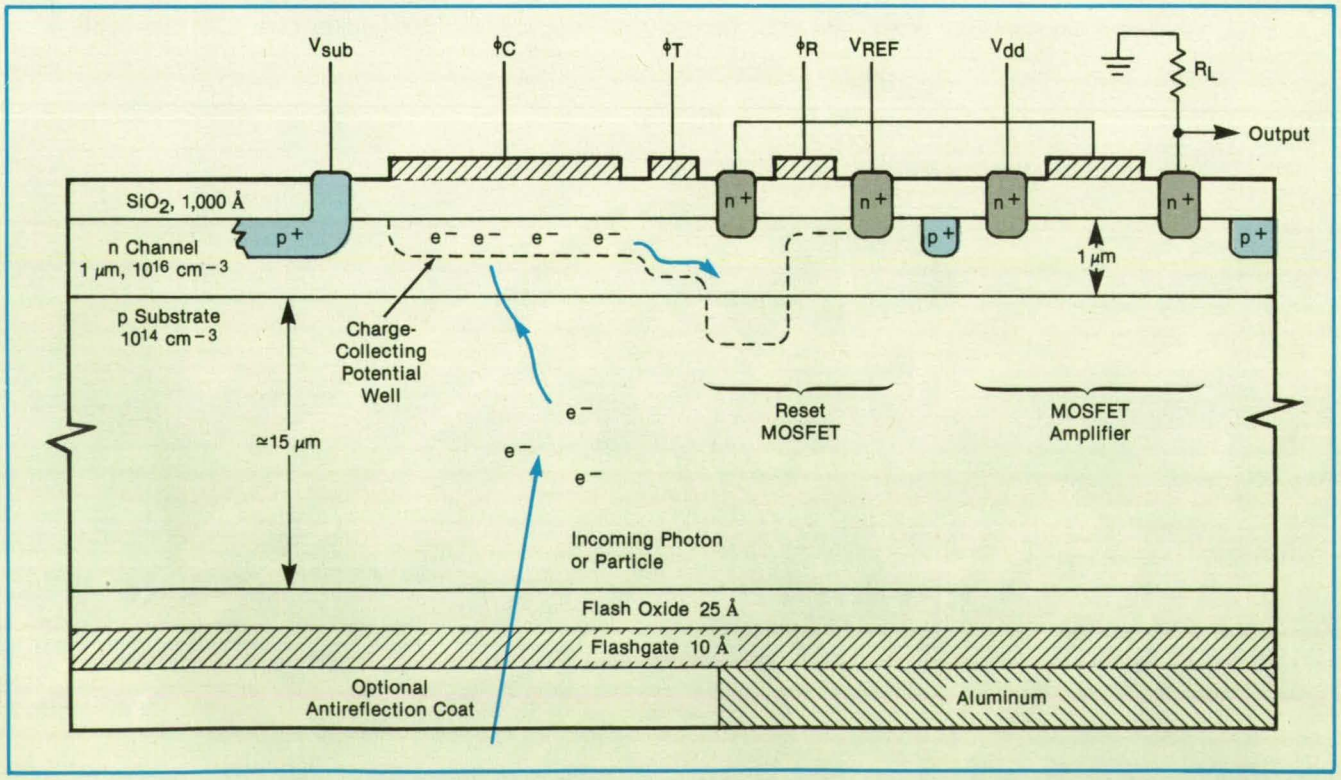
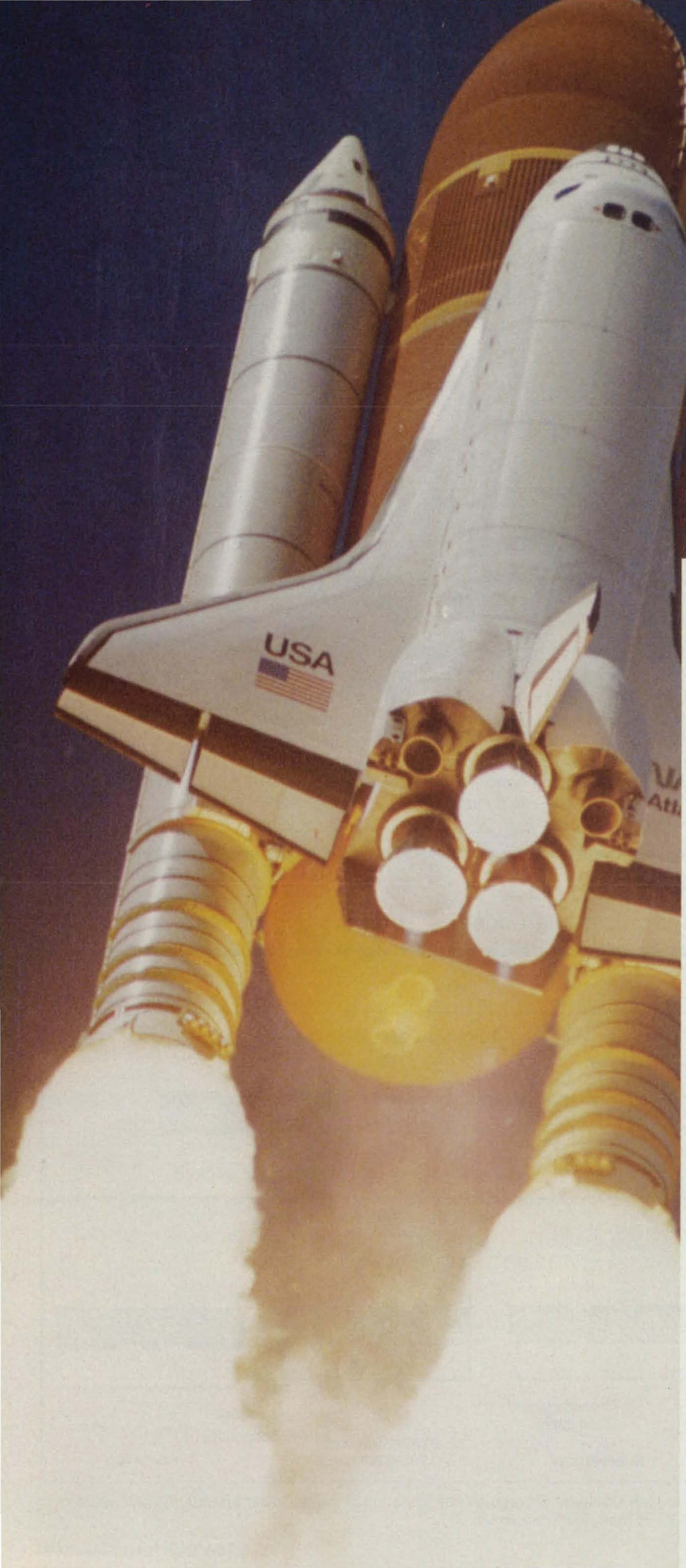


Figure 1. The **Flash-Coupled Photodetector** combines high quantum efficiency, charge-collection efficiency, and ultralow read noise.



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sweeps photogenerated electrons from the surface, where they would otherwise be lost to recombination. The collecting electrode (ϕ_C) shown in Figure 1 is biased positively and forms a depletion region that extends completely to the surface, establishing an electric field throughout the entire photosensitive volume of the detector. As a result of these two fields, the sensor exhibits 100 percent internal charge-collection efficiency and high overall quantum efficiency (see Figure 2).

Once a packet of signal electrons is collected, it is transferred through a transfer gate (ϕ_T) to a sense node that is connected to a high-performance metal-oxide/semiconductor field-effect-transistor (MOSFET) amplifier. The MOSFET is designed to deliver maximum conversion sensitivity (i.e., high volts/electron) in conjunction with low 1/f and white-noise characteristics, where noise levels of less than 2 e^- rms have been recently achieved. Low-noise performance in combination with high-collection capacity of the collecting electrode (several millions of electrons) produces a sensor with ultrahigh dynamic range in excess of 1,000,000.

After signal charge is read out, the sense node is reset (ϕ_R) by a reset MOSFET shown in Figure 1, preparing the sense node for a new charge packet. The flash-coupled photodetector is configured so that either a readout of the signal charge can take place while charge is being collected or the detector can be sampled continuously, depending on application.

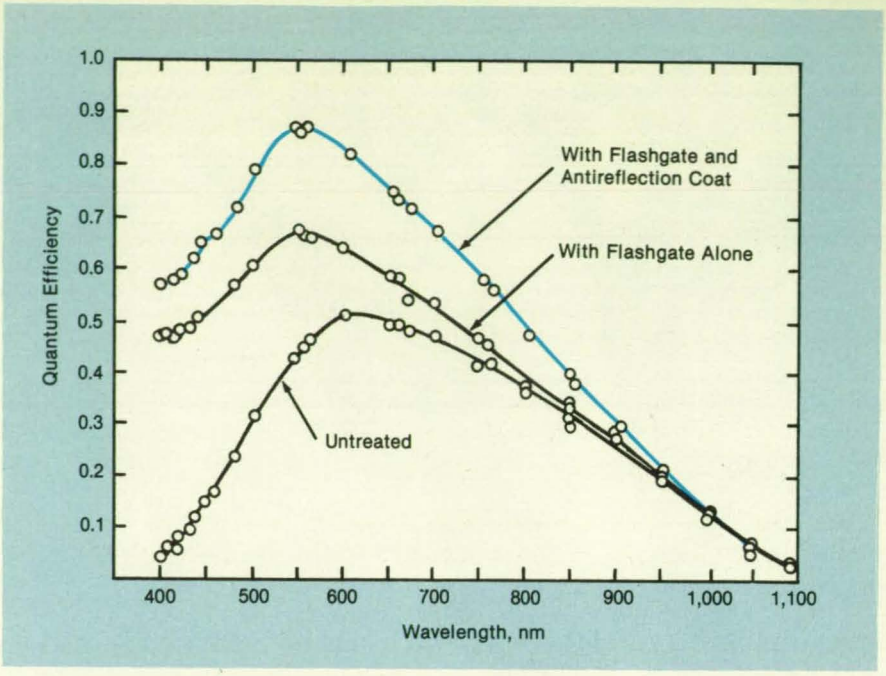

Figure 2. The **Quantum Efficiency** of the flash-coupled photodetector in the visible and near-infrared spectral region is enhanced by the flashgate and increased further by an antireflection coat.

This work was done by James R. Janesick of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 12 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-16963, volume and number of this NASA Tech Briefs *issue, and the page number.*

Improved Coplanar Waveguides

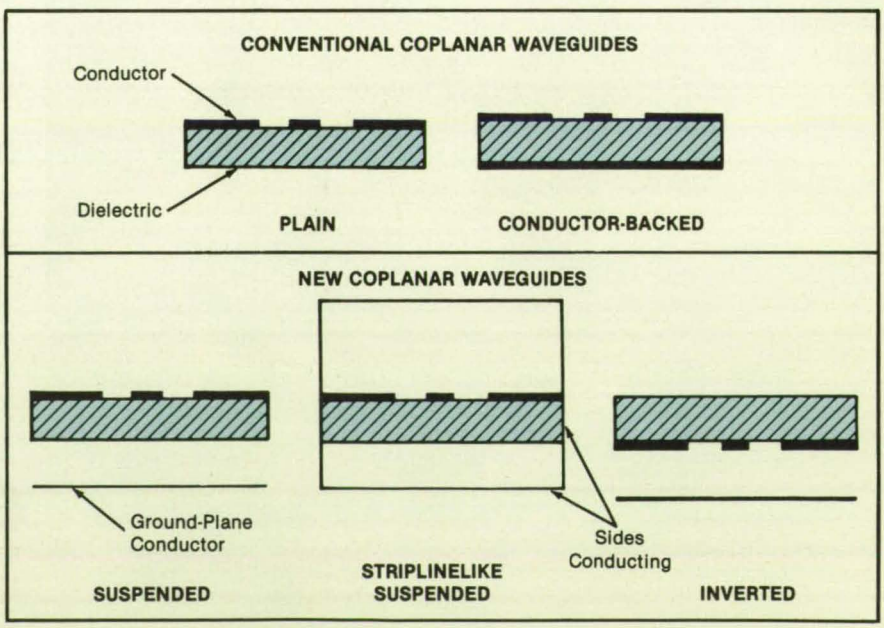
Features include less attenuation and looser tolerances. B89-10315

Lewis Research Center, Cleveland, Ohio

Three new types of coplanar waveguide transmission lines have been proposed: suspended, striplinelike suspended, and inverted. Numerical analyses of the propagation of the electromagnetic fields of the new and of the more-conventional plain and conductor-backed coplanar waveguides showed that the new waveguides offered several advantages over the conventional ones.

The ratios of the guide wavelengths to the free-space wavelengths in the new waveguides are closer to 1 so that the dimensions are larger and the tolerances correspondingly looser. The effective dielectric constants are lower, signifying that the electromagnetic-field energies are concentrated more in the air regions and less in the dielectrics; consequently, attenuation, which is due in part to losses in dielectrics, should be reduced.

For specified identical characteristic impedances and specified identical widths of strips, the new configurations have wider



Three **New Coplanar Waveguide** configurations promise lower attenuation and reduce the effects of manufacturing errors.

slots. Thus, low-impedance transmission lines can be realized with wider (therefore, easier-to-make) slots.

In an inverted coplanar waveguide, such active devices as Gunn and impact-avalanche-and-transit-time diodes can be mounted between the strip conductor and the metal trough. The metal trough also acts as an efficient heat sink. An electric-field-plane probe-type transition between a rectangular waveguide and a suspended coplanar waveguide can be constructed. This feature should have many uses in the testing of planar active devices and circuits like GaAs metal/semiconductor field-effect transistors and monolithic microwave integrated circuits operating at millimeter wavelengths.

This work was done by Rainee N. Simons of **Lewis Research Center**. *Further information may be found in NASA TM-89839 [N87-20469/NSP], "Propagation Characteristics of Some Novel Coplanar Waveguide Transmission Lines on GaAs at MM-Wave Frequencies."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LEW-14642

Microtronic Flow Transducer

B89-10216

This device is much smaller and more sensitive than existing flowmeters.

Lewis Research Center, Cleveland, Ohio

As an outgrowth of work sponsored by the NASA Lewis Research Center on research on deep impurities in silicon, a novel microelectronic airflow and gas-flow transducer has been developed. Unlike other gas-flow meters and transducers, this device has no moving parts and can be constructed by use of a variation on the ordinary technology for the processing of planar silicon microelectronics, where hundreds or indeed thousands of these identical devices can be concurrently produced on a single chip as easily as can one.

This device is fundamentally a Wheatstone-bridge semiconductor version of a hot-wire anemometer. The four legs of the Wheatstone bridge are identical silicon resistors, etched out of a solid single-crystal wafer (see Figures 1 and 2). Regardless of the ambient temperature, the bridge re-

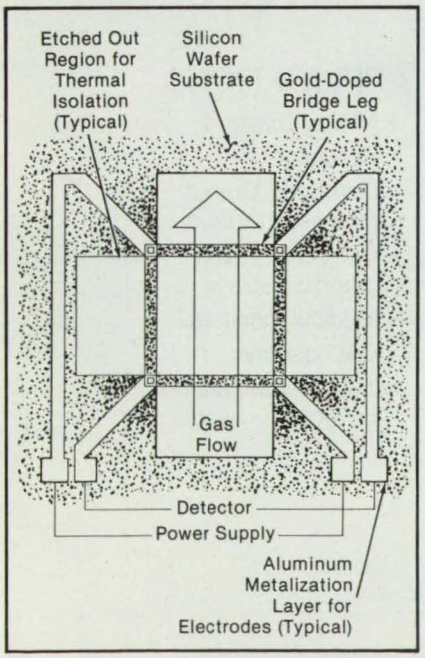


Figure 1. The **Gas-Flow Transducer** is based upon an integrated Wheatstone bridge in a silicon chip. The legs are doped with gold and isolated thermally by etching away the surrounding material (except the corners).

mains in balance, and its output voltage is zero unless air or gas flows across it. In the latter event, the flow cools the legs perpendicular to the flow more strongly than it cools the legs parallel to the flow.

Although the size of the device is in the range of 40 to 80 mils (1 to 2 mm) [because it is etched through a conventional 10-mil (0.25-mm) positively-doped metal-oxide/semiconductor wafer], in an epitaxial configuration the size can be reduced to the range of the thickness of the epitaxial layer. Techniques have been developed to etch away the substrate under the epitaxial layer and stop the anisotropic etching process at the interface between the epitaxial layer and the substrate.

This miniature electronic device, which provides a direct, sensitive voltage indication of flow, can easily be connected to simple digital or analog metering (often without supplementary electronics), or the signal can be used to activate other controls. However, because the device is fabricated on a conventional silicon wafer, auxiliary electronics and signal processing can be done on the circuit chip if desired. The sensitivity and range can be adjusted by adjusting the power-supply voltage and, therefore, the heating of the bridge legs. The sensitivities to flow that have been measured in the laboratory, even with a crude version of the device, exceed the sensitivity of any known commercial flowmeter.

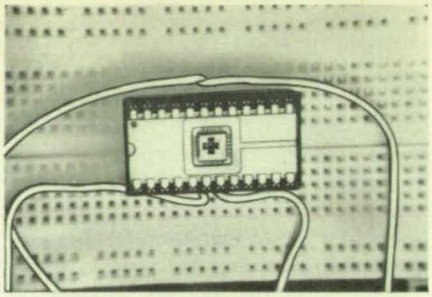


Figure 2. An **Integrated Circuit** contains a transducer like the one shown schematically in Figure 1.

The new microtronic mass-flow transducer has many potential advantages over present hot-wire anemometers, which are mainly reserved for specialized laboratory studies because they are so fragile and easily affected by contamination. The new transducer has a calculated sensitivity at least 100 times as high and a size 100 times as small. It can be passivated with either silicon dioxide, diamondlike films, or organic materials like parylene that form monolayers. Because of the high resistivity and sensitivity of the deep-impurity-doped silicon and the uniformity of single crystals, the new transducer is relatively insensitive to variations in temperature or pressure. It can be mounted in such a way as to make it reasonably rugged with regard to localized flows. In production quantities, the transducers (without ancillary processing electronics) should cost less than $1 apiece.

Because of the small size, sensitivity, and good directional capability of the new transducer, there are numerous potential applications in the measurement of vortexes, flows in inlets to pipes, and other complicated flows. It might be possible to build such planar devices directly into turbine blades or into the surfaces of aircraft to measure both magnitudes and directions of airflow.

The impetus for the device was the need for an electronic monitor to measure the postoperation breathing exercises of patients and prevent pneumonia. With associated electronics, the transducer could be used to provide information on lung function, or on the total intake of oxygen during a specified interval, or to sound an alarm. The transducer may lend itself to the more accurate monitoring and control of anesthetic gases during surgery. Another medical application would be to monitor the breathing patterns and to control the rate of flow of oxygen for premature infants.

This work was done by Gale R. Sundberg of **Lewis Research Center** *and H. T. Henderson and M. Walter. Hsieh of the University of Cincinnati. For further information, Circle 110 on the TSP Request Card.*
LEW-14654

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Electronic Systems

Optical Addressing and Clocking of RAM's

This approach could greatly increase computer operating speed.

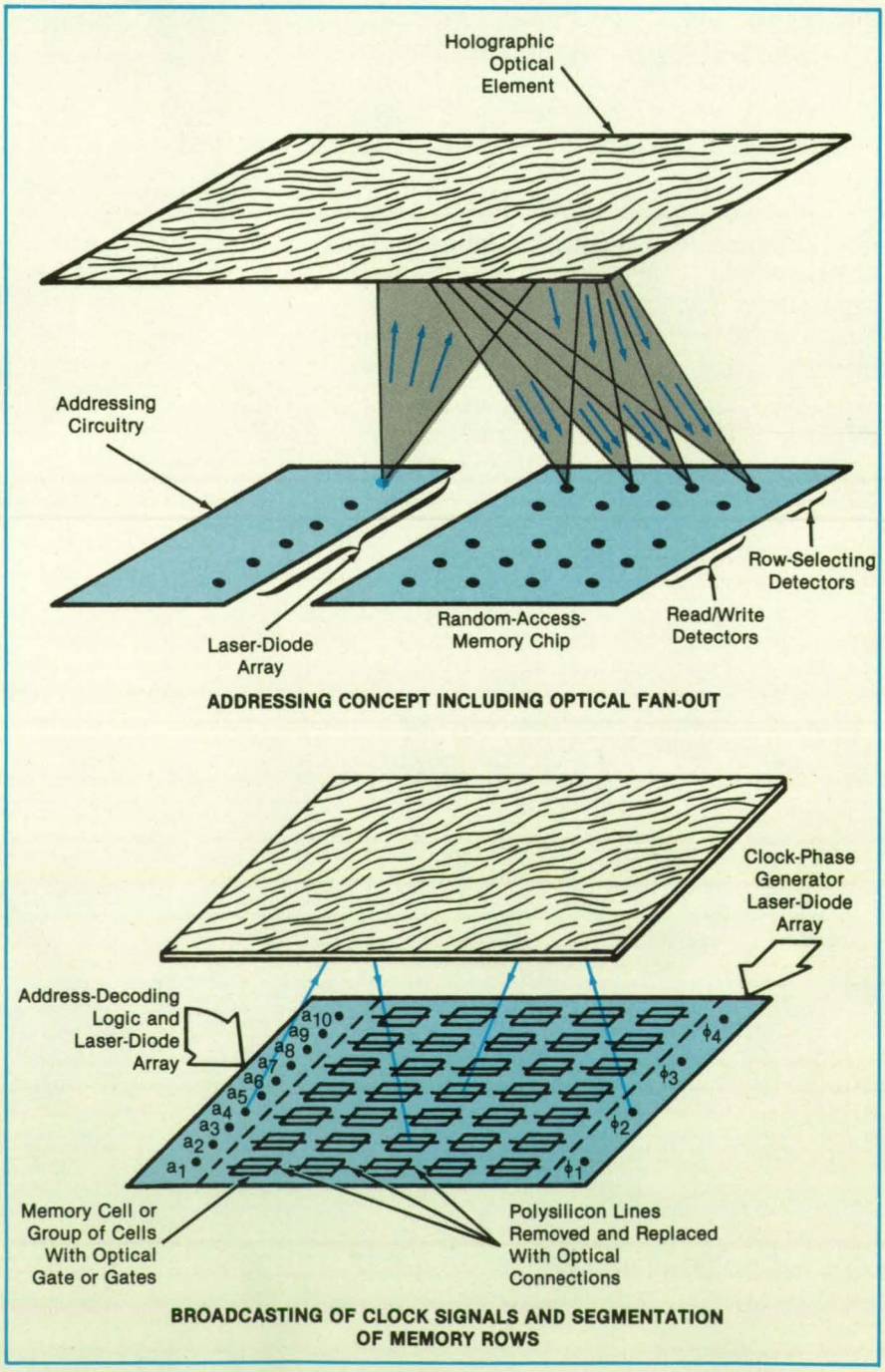
NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed random-access-memory (RAM) addressing system, in which the memory is linked optically to the read/write logic circuits, would greatly increase computer operating speed. The system — which comprises addressing circuits that include numerous lasers as signal sources, numerous optical gates that include optical detectors associated with the memory cells, and a holographic element to direct the light signals to the desired memory-cell locations — could be applied to high-capacity digital systems, supercomputers, and complex microcircuits.

A RAM is conventionally read or written via metal or polysilicon conductive strips connected from the edges of the memory chip to the multitude of memory cells, which are arranged in rows. Similar conductive strips are used to distribute the clock signals required by each cell to enable it both to retain and to pass on information. In a large RAM, the highly resistive and capacitative loads of the conductive strips cause a large portion of the transmission delays associated with the address and data lines that perform cell selection. In addition, the requirement of the mutual electrical isolation of all these conductive paths where they cross introduces severe geometric constraints on circuit designs.

To overcome these disadvantages, it is proposed to address the RAM and distribute clock signals by light signals transmitted through space outside the plane of the memory chip (see figure), thus reducing geometric constraints and increasing operating speed. The read/write logic is separated from the RAM proper, and individual diode laser sources are driven, each with one of the required access signals, thereby producing optical read/write signals. These light signals are directed to the required locations on the RAM by a holographic optical element. Special gate circuits, called optical input gates, each consisting of an optical detector (e.g., a photodiode) and an inverter, are used to transform the light signals to electronic-logic-level electrical signals usable by the RAM cells.

The holographic optical element (an ex-



Addressing and Clock Signals from laser-diode light sources are transmitted optically to optical gates at selected locations on the memory chip.

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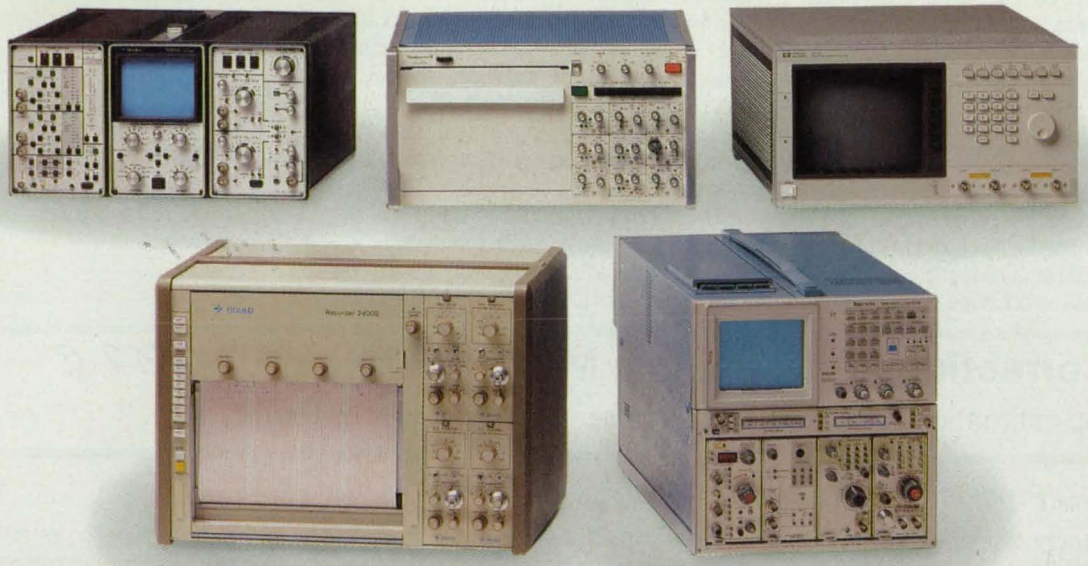

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isting device) functions somewhat in the manner of a focusing lens or mirror by intercepting the light signals directed away from the plane of the memory and refocusing the light at the required points. However, unlike a conventional lens or mirror, the holographic optical element can image one light source onto several detectors simultaneously. For example, a holographic optical element with a fan-out of four can be used in conjunction with four optical gates along each row of memory cells to divide the polysilicon line into shorter segments, thereby reducing signal-propagation delays along the line by a factor of 4. If each segment of the line is driven from the center, an additional reduction of delay by a factor of 2 will be obtained. Higher fan-out ratios will permit the overall RAM access speed to approach the memory-cell speed asymptotically.

This approach is ideally suited to broadcasting clock signals. Because the same clock signal is typically used for all cells, optical broadcast clock distribution is an efficient method of providing timing for the chip. Using current silicon very-large-scale integration, a single laser source could broadcast a clock signal via an holographic optical element to a two-dimensional array of silicon detectors, each placed at a memory cell.

This work was done by Alan R. Johnston, Robert H. Nixon, Larry A. Bergman of Caltech and Sadik Esener of the University of California for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 135 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use of this invention should be addressed to

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Refer to NPO-16981, volume and number of this NASA Tech Briefs *issue, and the page number.*

Fast Correction for Doppler in MDPSK Signals

B89-162 18

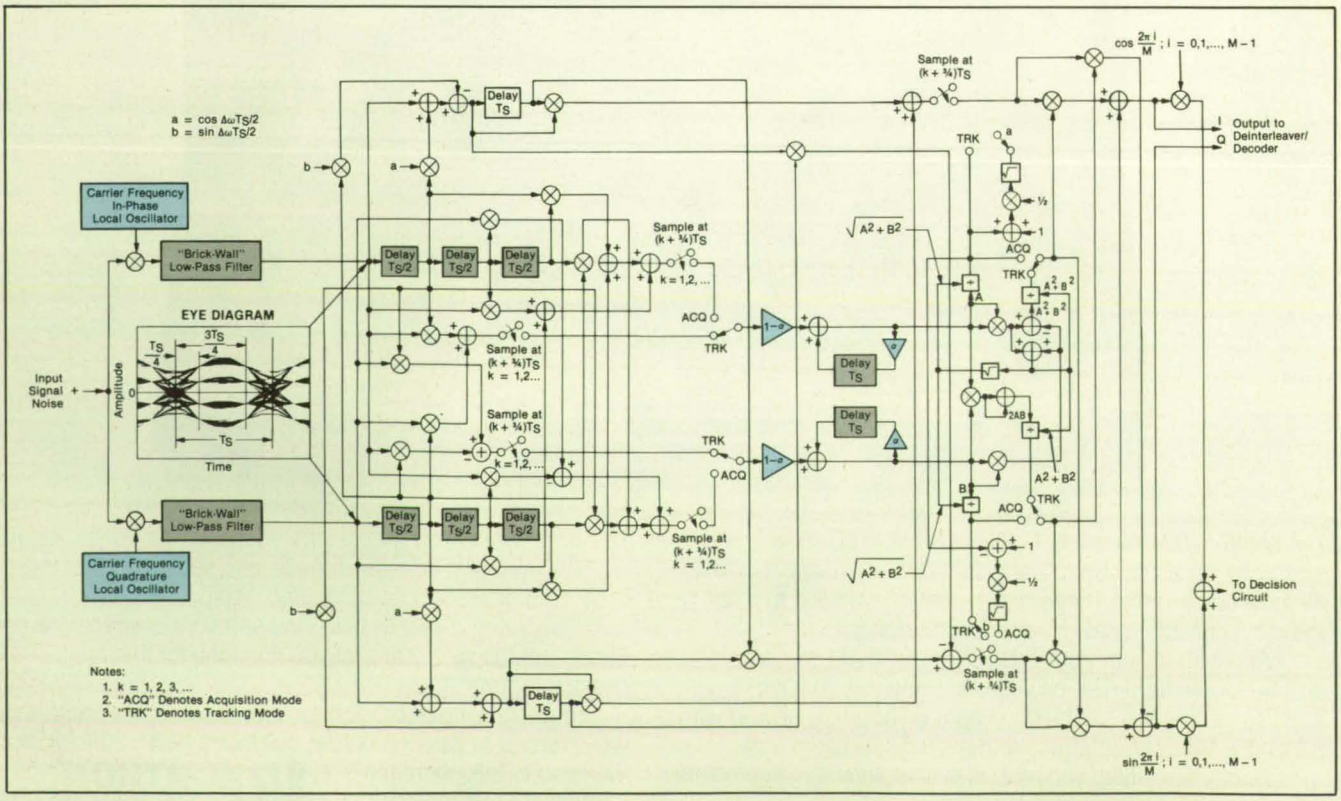
Open-loop estimation of frequency and differential detection are combined.

NASA's Jet Propulsion Laboratory, Pasadena, California

A detector of multiple differential phase-shift-keyed (MDPSK) signals is being designed to effect a combination of open-loop estimation of frequency and differential detection of digital modulation. The improved design is expected to decrease the probability of bit errors in situations in which the carrier frequency is uncertain and signals are transmitted in bursts that are too short to allow closed-loop tracking of the carrier frequency — for example, in the transmission of digitally-coded voice signals in land-mobile/satellite communications at ultra-high frequencies.

The design of the detector is based in part on the fact that whereas the change in phase of the received signal during a full symbol period contains the sum of the data phase and the Doppler-induced phase shift, the change in phase during half a symbol period within a given symbol interval contains only the Doppler-induced phase shift. Thus, by a combination of full-symbol and half-symbol differential detection together with suitable processing (including postdetection integration), the Doppler component can be estimated and removed.

The figure illustrates a baseband version for the detection of 8DPSK signals. The Doppler shift is estimated in two modes: acquisition and tracking. In the tracking mode, the estimate is updated repeatedly in the presence of the input 8PSK data signal. Samples are taken at the $3T_S/4$ point in each symbol period T_S. The samples reflect multiplications of the in-phase (I) and quadrature (Q) values of signal plus noise at $T_S/4$ and $3T_S/4$. In principle, the means of the I and Q samples are proportional to the cosine and sine, respectively, of the Doppler component of the phase shift during half a symbol period, and this would enable



This **8DPSK Differential Detector** operates in a tracking or an acquisition mode to correct for Doppler shifts.

TEAM WORK

ZB-A2

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the calculation of the Doppler component.

The problem of estimation is complicated somewhat when the data pulses are not rectangular. However, if the pulses are shaped by raised-root-cosine filtering at the transmitter and "brick-wall" low-pass filtering at the receiver, the sine and cosine conditions are still met at the $T_S/4$ and $3T_S/4$ points, enabling the estimate to be made. In addition, a normalizing gain of $1-\alpha$ at the input to the sample accumulator and a gain of α in the feedback path cause the system to weigh the most recent samples most heavily and to give exponentially decaying weight to previous samples.

To remove the Doppler component from the I and Q samples used to detect data, it is necessary to compute

$$\cos\left[2\tan^{-1}(B/A)\right] = \frac{A^2-B^2}{A^2+B^2}$$

and

$$\sin\left[2\tan^{-1}(B/A)\right] = \frac{2AB}{A^2+B^2}$$

where A and B are the outputs of the sample accumulators as indicated in the figure.

Ordinarily, the I and Q samples used to detect data would be taken at the middle ($T_S/2$) of each symbol period. To recover a 3-dB loss in the signal-to-noise ratio due to sampling at the $T_S/4$ and $3T_S/4$ points and shaping of the pulse, the samples are weighted by a and b (see figure) and added in the data-detecting section before differential detection.

In the acquisition mode, a known sequence of data symbols — for example, all zeros — is transmitted. Thus, the change in modulation phase is known (e.g., zero) during a symbol period, and one can use the data-detection samples to estimate the Doppler component of phase shift. Also, because these samples are proportional to the cosine and sine of the Doppler component of the phase shift during T_S (rather than $T_S/2$), the outputs of the accumulators can be used directly to remove the Doppler component from the data-detection samples.

The processing of the outputs of the detector depends on whether the modulation contains uncoded or coded data. In the case of uncoded data, one simply makes decisions on the detector outputs in the same manner as in a conventional (not Doppler-corrected) MDPSK receiver. For coded transmission, the detector outputs are quantized to implement the soft-decision decoding metric.

This work was done by M. K. Simon and D. Divsalar of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 136 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA's Resident Office-JPL [see page 18]. Refer to NPO-16987.

Optical Firmware

B89-10319

Central-processor instructions would be contained in a holographic optical element.

NASA's Jet Propulsion Laboratory, Pasadena, California

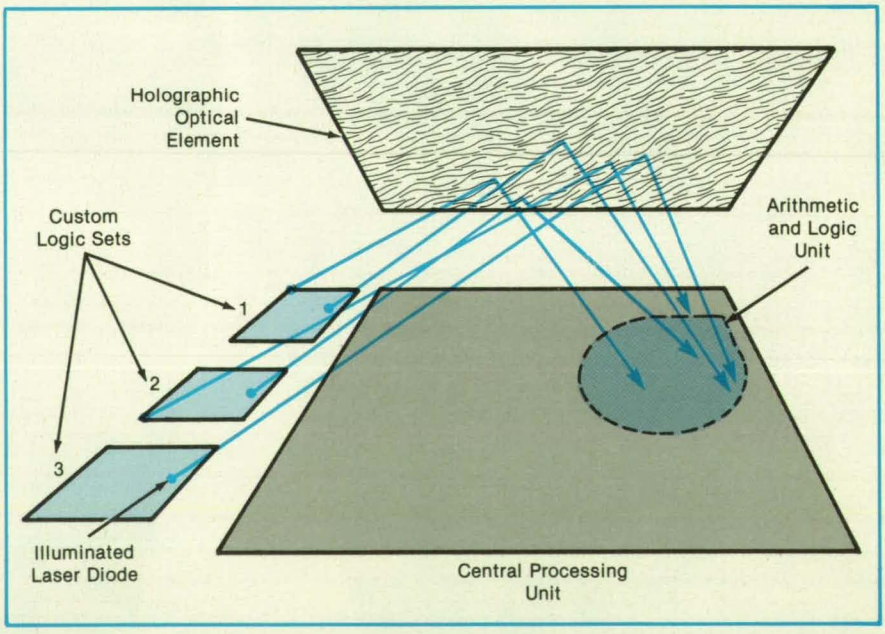
A conceptual data-processing system would exploit the high speeds inherent in optical elements. The sets of instructions for the central processor of the system would reside in a holographic optical element physically separated from the arithmetic and logic unit. Light signals embodying the instructions would be transmitted through the volume above the processor plane (see figure), thereby overcoming the constraints that are typically imposed on designs by planar computer-chip layouts.

Attempts to increase computing speed have motivated the recent efforts to build reduced-instruction-set computers, which are compact and fast but which can be built to perform only limited sets of operations. The new computer concept extends the reduced-instruction-set concept. Several reduced-instruction-set patterns would be overlaid on a common very-large-scale-integration substrate containing the arithmetic and logic unit. Each pattern could contain the instructions for a different operation; for example, a Boolean operation, convolution, or a control function. To activate a particular subset of instructions, a specified subset of laser diodes would be turned on; the light from the diodes would be reflected by the holographic optical element onto a corresponding subset of photodiodes in the arithmetic and logic unit.

Fixed instruction sets would be contained in a permanent hologram. If the hologram is electrically programmable, the instruction set could be changed — possibly as fast as the system clock rate. For the highest speed and the largest instruction size, an optically programmable holographic element might be developed using light-valve technology.

It might be possible to modulate the hologram with an input image; for example, using changing images of a speaker's lips to produce different sounds or using images of text to generate control functions. With the potential ability to reprogram itself in real time, the conceptual system would be particularly applicable to task-driven programming or artificial intelligence.

The concept might be applied to a data-security system in which an integrated circuit would serve as a lock and a holographic optical element as the key. A fingerprint might be mapped onto the holographic element to configure the system to a specified digital state or polynomial representing the



Instruction Sets for Different Computer Operations reside on different external memory chips. Laser diodes activated for each operation generate light, which is reflected by the holographic optical element to designated receptors in the arithmetic and logic unit. The pattern of light beams embodies the instruction set at a given instant.

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"locked" or "unlocked" condition. For repeated calculations in intensive numerical analysis, the instructions for such frequently used transcendental functions as the trigonometric and error functions could reside on external memory chips and be used to activate sets of laser diodes.

This work was done by Larry A. Bergman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 132 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquires concerning rights for its commercial use should be addressed to

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Refer to NPO-16984, volume and number of this NASA Tech Briefs *issue, and the page number.*

Alignment System for Docking Control

B89-10220

The direction and polarization of a light beam would provide attitude references.

Lyndon B. Johnson Space Center, Houston, Texas

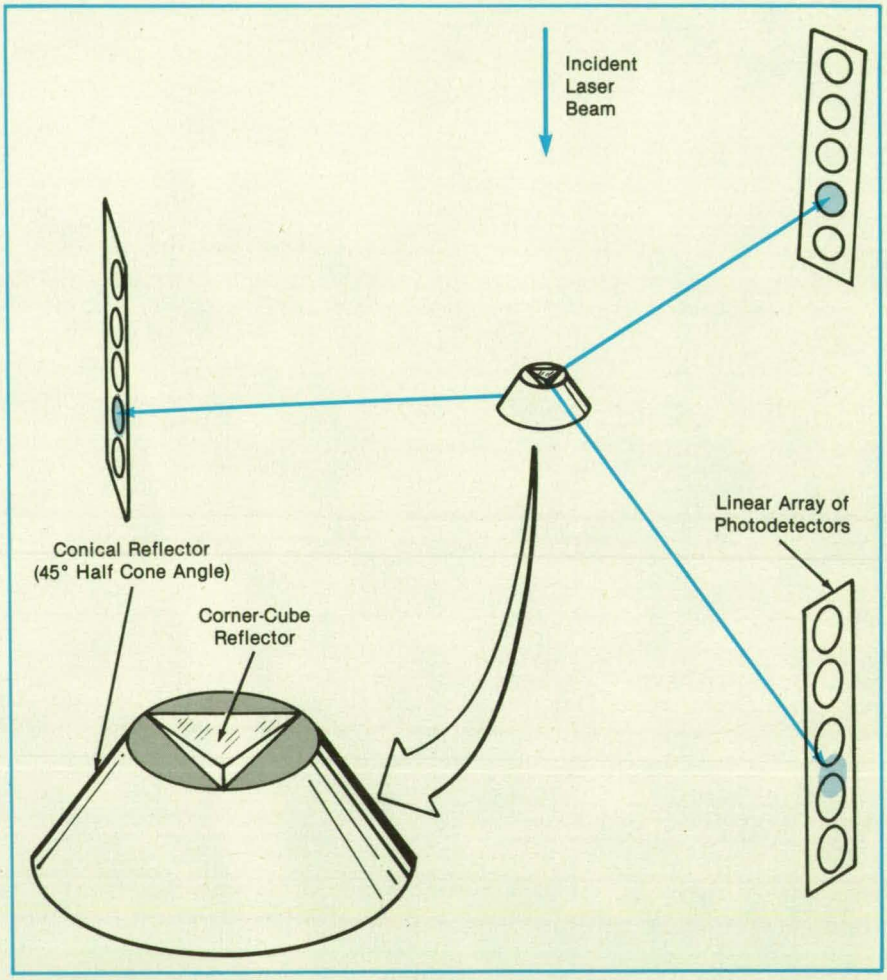
A concept for the alignment of a vehicle approaching a station is based on the generation of a coherent, polarized light or microwave beam by the station and the measurement of the beam propagation and polarization axes by the vehicle. Intended originally for use in the docking of a spacecraft with a space station, the concept may be useful for the refueling of aircraft in flight and in robotics.

In a typical one of many versions of the conceptual system, the station searches for the vehicle optically until it senses a corner-cube or other retroreflector that lies in the middle of a conical reflector (see figure). A laser in the station generates a linearly polarized light beam, which then remains aimed at the moving retroreflector as the station tracks the moving vehicle.

The conical reflector is placed on and oriented along the alignment axis of the vehicle. Three linear arrays of photodetectors, each much longer than the cone, are placed at a distance much greater than the length of the cone to catch reflected portions of the laser beam. When the laser beam and the axis of the cone are parallel (vehicle aligned), the laser beam is reflected from the cone, spreading out in a disk perpendicular to the cone. In that case, the light is intercepted by the middle photodetector or group of photodetectors in each array.

If the light beam and the axis are not parallel, the light can fall on a photodetector above or below the plane of the disk. In either case, the direction of the vehicle axis relative to that of the beam can be calculated from the positions of the three photodetectors receiving the light reflected from the cone.

The angle of roll of the vehicle about the light beam is measured by reference to the polarization axis. The cancellation of light by a polarizing filter easily establishes the polarization axis, with an ambiguity of ±180°. For roll-attitude control or for the measurement of the roll angle plus or minus the ambiguity, the incident light can be passed through two polarizing filters at 90° to each other, each covering a separate photodetector. The outputs of the photodetectors can be compared to determine the roll angle. The photodetectors can be connected in a bridge circuit to generate a null control signal to maintain a desired roll angle.



Conical and Corner-Cube Reflectors on the vehicle disperse portions of the incident light beam to sensors on the vehicle and station, respectively. The station uses the return signal for ranging and tracking. The known mathematical relationship among the direction of the beam and the positions of reflected light on the photodetector arrays can be used to calculate the orientation of the vehicle.

The distance between the station and the vehicle can be measured with the tracking-and-orienting laser beam, using one of the well-known pulse- or frequency-modulation techniques. The laser signal could also be amplitude modulated or frequency -modulated to send control signals to the vehicle, provided that the control modulation is of a type that does not interfere with the ranging function.

This work was done by Richard S. Iwasaki of Axiomatix for **Johnson Space Center**. *For further information, Circle 83 on the TSP Request Card.*
MSC-21156

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Circle Reader Action No. 660

Physical Sciences

Magnetic-Flux-Compression Cooling Using Superconductors

Leakage of heat would be reduced.

B89-10221

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed magnetic-flux-compression refrigeration system would produce final-stage temperatures below 4.2 K. Like other magnetic refrigeration systems, this one promises to be more efficient than mechanical and sorption refrigerators are at temperatures in this range. The proposed system should weigh less than do comparable liquid-helium-cooled superconducting magnetic refrigeration systems that operate below 4.2 K.

In the proposed system, the magnetic field would be compressed in an electromagnet made of one of the newly discovered superconductors that have transition temperatures above ~90 K. The higher operating temperatures (compared to those of other systems based on superconductivity) should reduce the size of, and demands upon, the refrigeration stages that cool the final stage. Because the heat would be lost from the magnet at a higher temperature, the low-temperature efficiency would be increased.

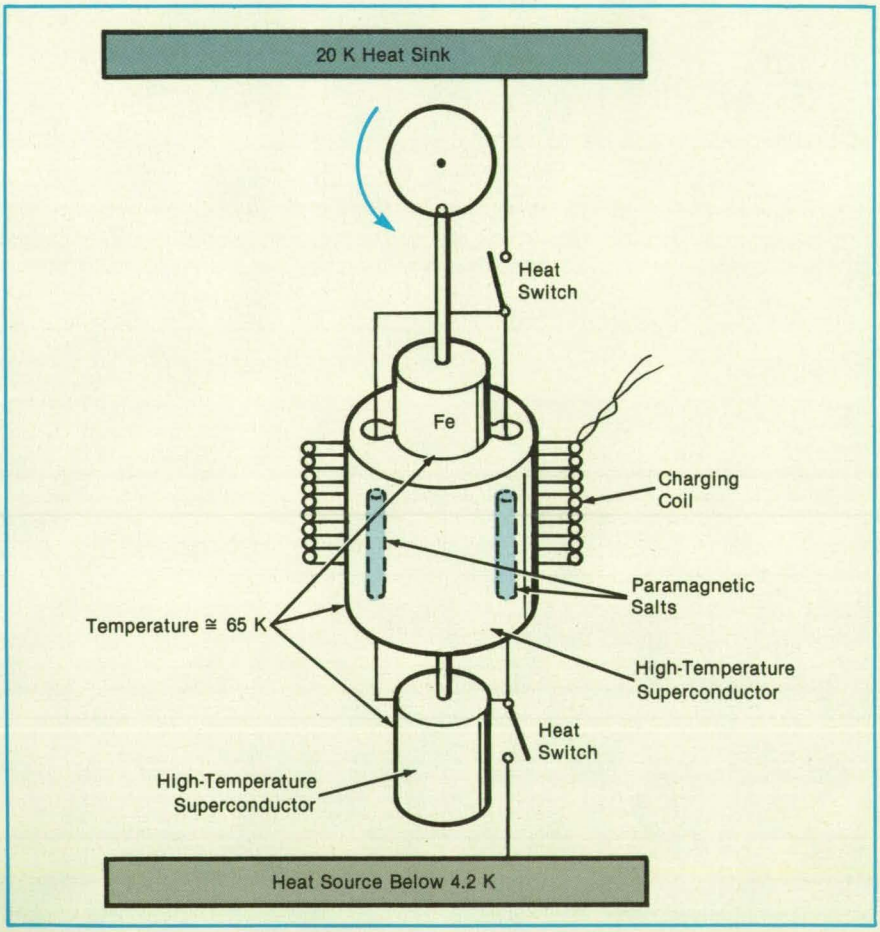
The final refrigeration stage (see figure) would typically include a body made of a high-temperature superconductor. Two small holes in the body would be connected to a large hole by a gap of small cross-sectional area. The small holes would contain a paramagnetic salt. A soft-iron cylinder and a superconducting cylinder would be placed in the large hole alternately during each refrigeration cycle.

During normal operation, this stage would be cooled below the critical temperature for superconductivity. However, to charge the stage initially (or to recharge the stage after a number of cycles of operation) with magnetic field, it would be temporarily heated above the critical temperature by an embedded heating coil while an external coil applies the charging magnetic field. During charging or recharging, the large hole would be occupied by the soft-iron cylinder to intensify the magnetic flux within it. After charging, the heating coil would be turned off, thus "turning on" the superconductivity and trapping the magnetic flux in the superconducting body.

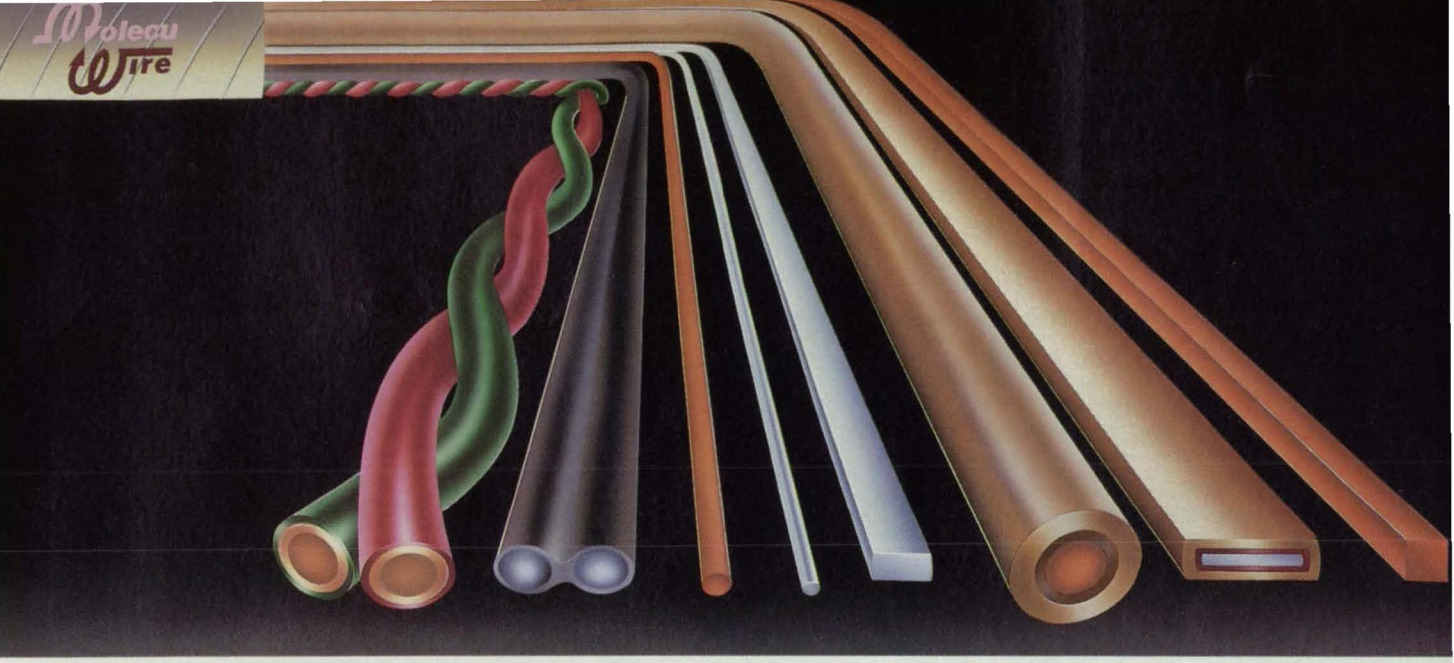
The cyclic operation of the refrigerator would then begin. During the first half cycle, the superconducting cylinder would be inserted in the large hole to compress the magnetic flux through the gaps into the small holes, the lower heat switch would be opened, and the upper heat switch would be closed. The heat generated by the magnetization of the paramagnetic salt would be transferred through the upper heat switch into the 20 K heat sink.

During the second half cycle, the superconducting cylinder would be withdrawn and replaced by the soft-iron cylinder to draw the magnetic flux from the small holes back into the large hole. The upper heat switch would be opened and the lower heat switch closed so that the cooling of the paramagnetic salt due to demagnetization could be used to draw heat from the low-temperature heat sink or specimen to be cooled.

Only a small amount of magnetic flux should have to be supplied initially, and, because little magnetic flux is lost during each cycle, the need for recharging should be reduced. These features should reduce



The **Magnetic-Flux-Compression Refrigerator** would be the final cooling stage in a refrigeration system that produces temperatures below 4.2 K. The stage would combine the advantages of some newly discovered superconductors with those of cooling by magnetization and demagnetization of paramagnetic salts.



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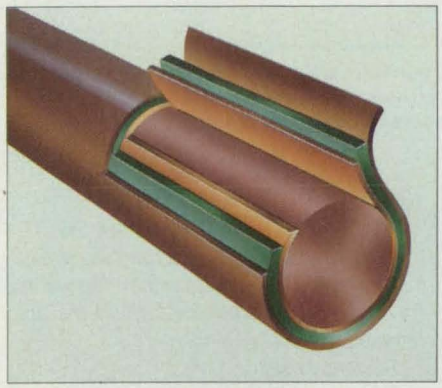

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the leakage of heat and increase the energy efficiency of the system.

This work was done by Donald M. Strayer, Ulf E. Israelsson, and Daniel D. Elleman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 25 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-17504

Strain-Layer-Superlattice Light Modulator

One light beam would control another.

B89-10222

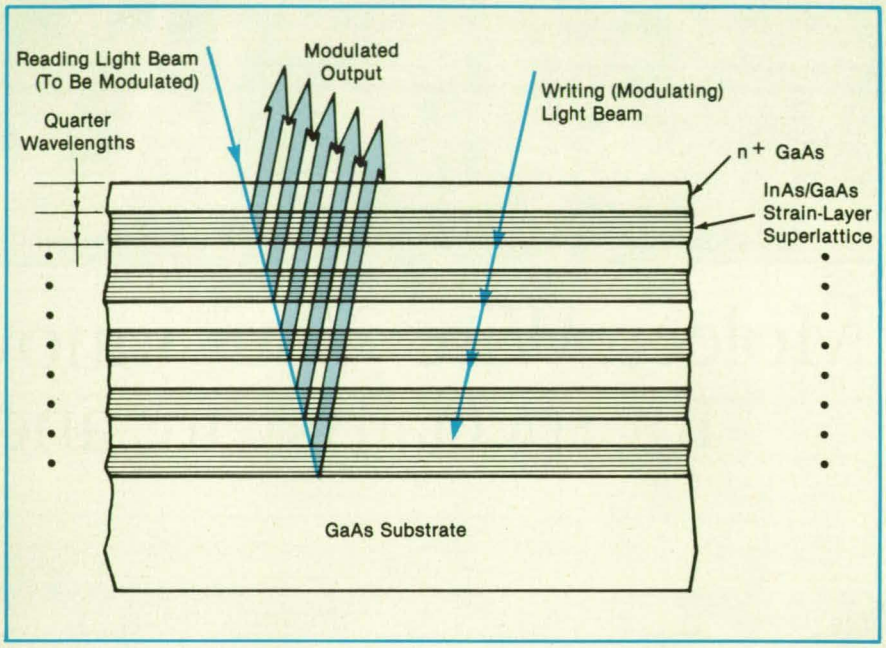
NASA's Jet Propulsion Laboratory, Pasadena, California

A conceptual device would combine resonant reflection and photovoltaic action to enable one light beam to impose spatial and temporal modulation on another light beam. Such a spatial light modulator, with its high speed and multiplicity of parallel signal channels, could be used in image processing or similar computation requiring high data-throughput rates.

The device would be made of layers of n^+ GaAs alternated with strain-layer-superlattice layers of InAs/GaAs (see figure). Recent advances in molecular-beam epitaxy have made it possible to grow such semiconductor microstructures, with a lattice mismatch of more than 7 percent between the InAs and GaAs layers. If the thickness of each InAs layer is made 5 nm or less, the strain due to the mismatch can be confined mostly to the InAs, giving rise to a strong tetragonal distortion without forming misfit dislocations. This strain strongly modifies the electronic-energy-band structure and has been predicted to lead to enhanced electro-optical effects when grown on <111> oriented substrates.

The thickness of each n^+ GaAs layer and each superlattice layer would be made a quarter of the wavelength of the light to be modulated (the "reading" signal). This wavelength would be chosen to correspond to a photon energy slightly less than the band gap of the strain-layer superlattice so that the change of index of refraction (electro-optic effect) would be large and the absorption of the read signal would be low. Each pair of quarter-wave layers would contribute to the resonant reflection of the reading light, reinforced by the resonant reflection from the other pairs of layers.

The device would also be illuminated by the modulating light beam (the "writing" signal). The photon energy of this beam would be chosen to be greater than the GaAs band gap so that these photons could generate photocurrents at the boundaries of the quarter-wave layers. Changes in refraction induced by the photocarriers would change the index of refraction and thus the optical path lengths in the layers and would thereby modulate the resonant reflection of the reading signal.



Microstructures of GaAs and InAs with multiple quantum wells and compositional superlattices would be grown by molecular-beam epitaxy. The enhanced electro-optical properties of this arrangement of alternating layers would enable the writing light beam to modulate the reading light beam.

This work was done by Joseph Maserjian of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 105 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-16915, volume and number of this NASA Tech Briefs *issue, and the page number.*

Apparatus Makes Precisely Saturated Solutions

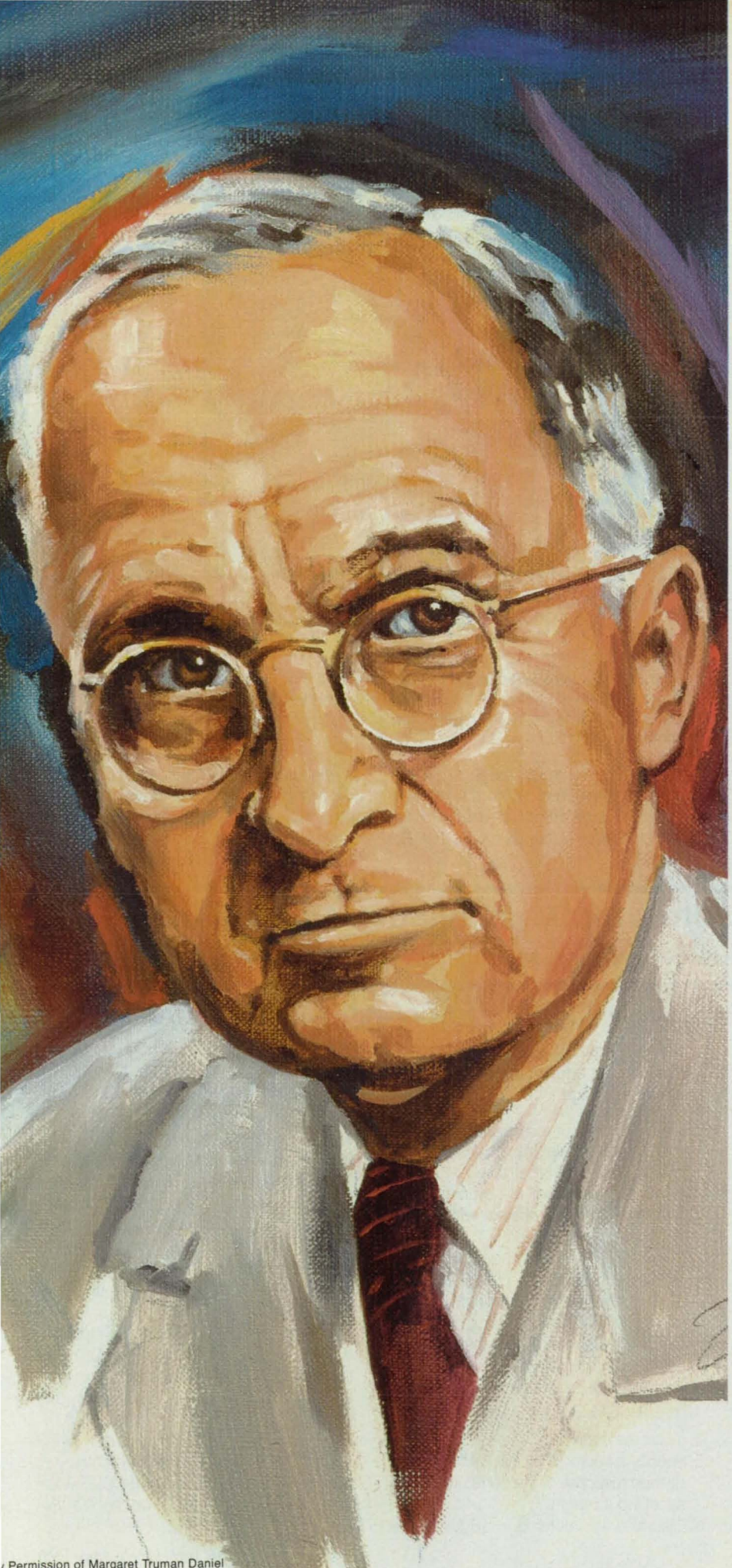
Measurements of saturation conditions are accelerated.

B89-10223

Marshall Space Flight Center, Alabama

A simple laboratory apparatus establishes equilibrium conditions of temperature and concentration in solutions for use in precise measurements of the saturation conditions. With this equipment a typical measurement of the saturation concentration of a protein in solution can be established and measured within about 24 hours, whereas prior techniques and equipment required about 8 weeks for such a measurement. Thus, the apparatus is particularly useful for such repetitive measurements as those necessary to establish multiple-constituent or temperature-versus-concentration phase diagrams.

The apparatus (see figure) includes a regulated-temperature bath that maintains a column within 0.01 °C of the desired temperature. The column is packed with a slurry consisting of the solution and fine particles of the solute. The lower end of the column



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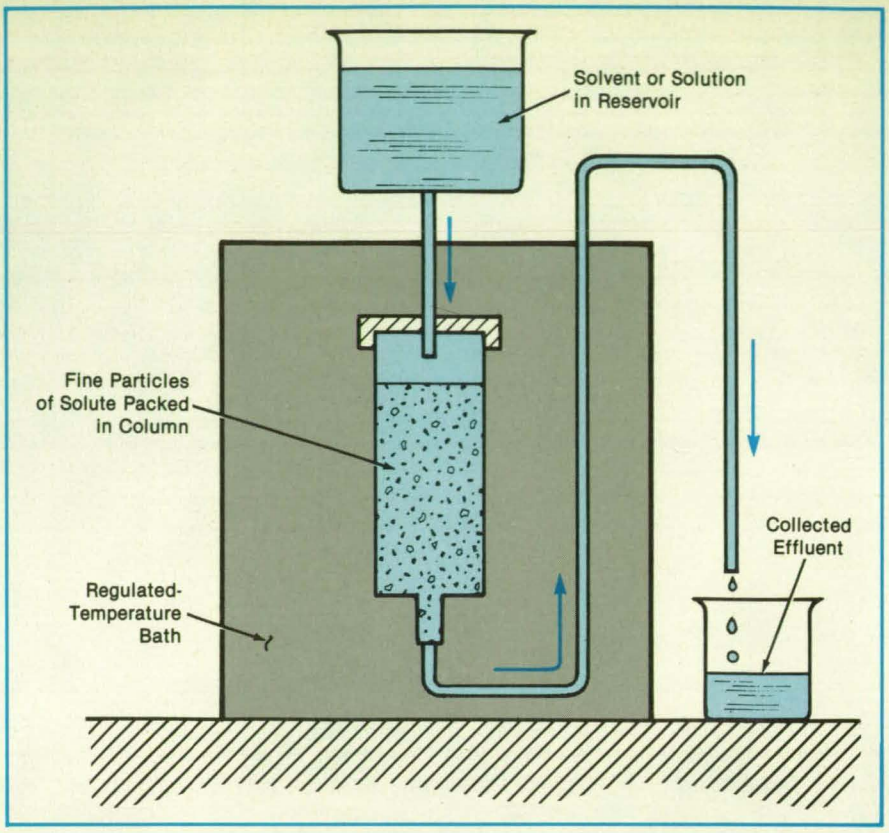
is plugged with fine glass wool to prevent particles of solute from falling out. The solvent or solution is fed from a reservoir into the upper end of the column, and the effluent from the lower end of the column is collected. The concentration of the solute in the effluent solution is measured by the applicable conventional technique.

Provided that the flow of solvent is slow enough, the effluent should be a saturated solution. If it is suspected that the solute in question crystallizes or dissolves too slowly to come to equilibrium with the solvent before the solution has passed along the column, then the flow is interrupted for the time necessary to establish equilibrium — usually 24 hours or less. Then the effluent is collected in several volume fractions, each about one-twentieth of the volume of the column, and the concentrations in these fractions are measured. The temperature can then be changed to the next value, while the flow remains stopped to establish the new equilibrium.

The nearness to saturation in a simple column can be examined by use of two columns operating at the same temperature. The reservoir of one column is filled with a supersaturated solution, while that of the other column is slightly undersaturated. The concentrations of solute in the effluents of the two columns then represent outer limits between which the saturation concentration must lie. If the two concentrations differ by less than the limits of accuracy of the measurements, then it can be assumed that equilibrium is established in the column. If the two concentrations differ, then the flow must be stopped for a longer time to assure equilibrium.



A **Precisely Saturated Solution** is made by passing a solvent or solution slowly along a column packed with the solute at a precisely controlled temperature. If necessary, the flow is stopped for an experimentally determined interval to allow equilibrium to be established in the column.

This work was done by Marc L. Pusey of **Marshall Space Flight Center**. *For further information, Circle 92 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 18]. Refer to MFS-28280.

Synthetic Estimation Filters for Determination of Position

The position and orientation of a target would be determined by optical correlation.

Lyndon B. Johnson Space Center, Houston, Texas

B89-10224

The concept of the synthetic estimation filter (SEF) has been proposed to extend the concept of the matched filter from mere recognition of an object to recognition of its position and orientation relative to the observing apparatus. An optical filter of this general type is correlated with an input image to obtain a signal indicative of the match between the input and filter images. The operation of the SEF depends on a property that is a disadvantage in a matched filter designed solely for recognition: Such a filter works only when the input image is oriented, sized, and positioned identically to the filter image. The correlation signal falls rapidly when the object in the input image is rotated and/or made to approach or recede from the orientation and/or position represented in the matched filter.

The following is the procedure for generation of an SEF that can be used to estimate the position and/or orientation of an object with respect to one or more parameter(s); e.g., distance, rotation about the line of sight, or rotation about a line in the plane of the image.

1. Generate a set of matched filters $M_k = [F\{I_k\}]^*$ from Fourier transforms F of input images I_k of the target taken at a sufficiently large number of positions k that cover the range of interest with the desired resolution.
2. Convert each matched filter M_k to a filter M'_k of the type (e.g., a phase-only filter) required by the optical correlator.
3. Using the kth matched filter, determine the maximum response of the correlator to the ith input image. Repeat for all i and k to generate the matrix
$$A_{ik} = \max [F^{-1}\{M'_k * F\{I_i\}\}]$$
4. Invert the matrix A_{ik}.
5. Specify a vector $\mathbf{D} = \{D_i\}$, which is the desired response of the correlator for the set of input images I_i.
6. Calculate the vector $\mathbf{B} = \{B_k\}$, which is the synthetic-filter coefficient, using $\mathbf{B} = A^{-1}\mathbf{D}$.
7. Form the SEF, which is a composite set of matched filters, from the sum
$$\text{SEF} = \sum_k B_k M_k$$
8. If required, convert the matched SEF to a filter SEF′ of the type required by the optical correlator. For example, if a phase-only filter is required, then SEF′ = SEF/|SEF|.

The set SEF′ can be used to estimate the range and orientation of the target by looking at two views corresponding to positions on each side of that of the input image. Using the expression for **D**, interpolate the position and/or orientation from the distances to the two affected views in the SEF′.

This work was done by Richard D. Juday of **Johnson Space Center** *and Stanley E. Monroe, Jr., of Lockheed/EMSCO. For further information, Circle 91 on the TSP Request Card. MSC-21418*

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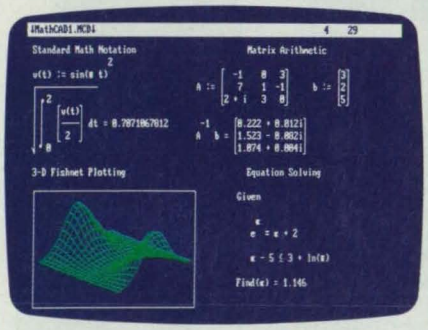

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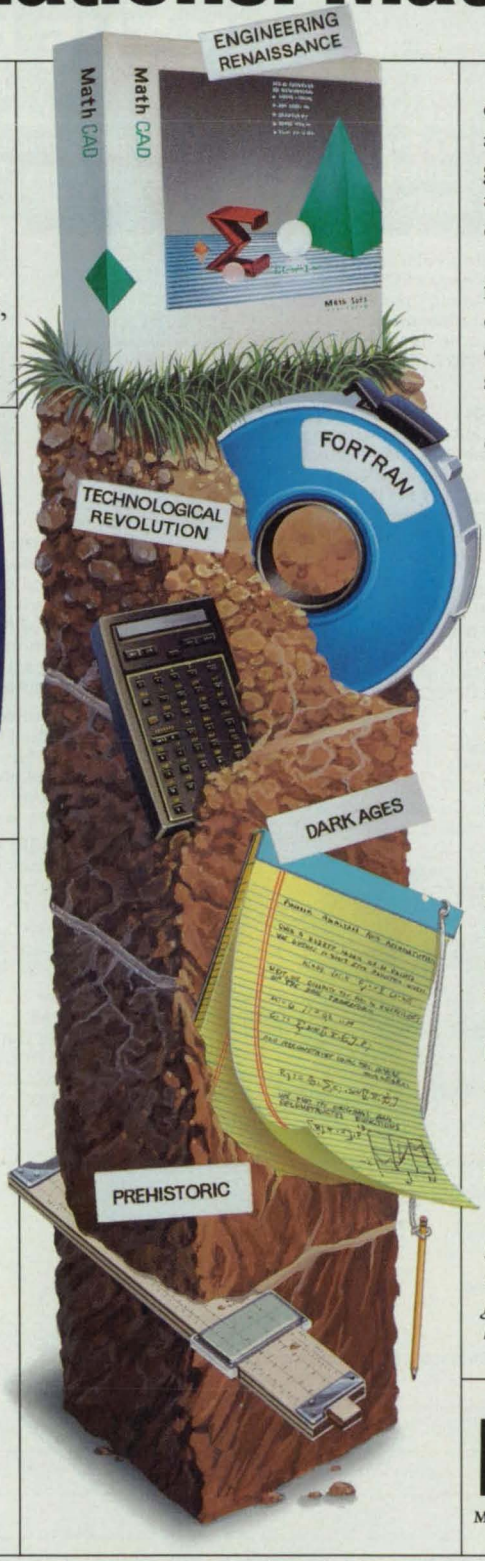

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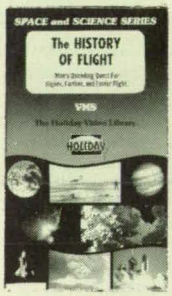

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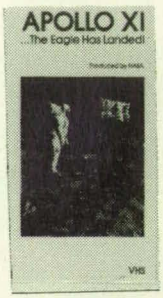

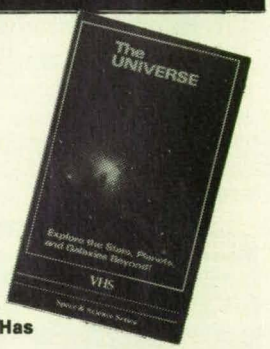

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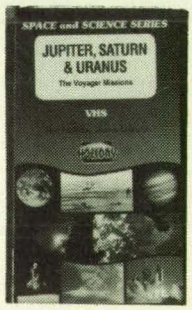

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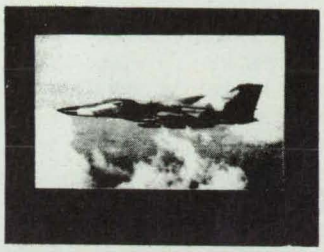

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B89-10225

Heated Rack for Weathering Tests

Aging of the tested material is accelerated, but under almost-natural conditions.

NASA's Jet Propulsion Laboratory, Pasadena, California

The outdoor photothermal aging reactor (OPTAR) is a simple device that exposes polymer specimens to both heat and natural sunlight. The device is intended to provide accelerated aging data for the service life of polymers used in an outdoor environment. In principle, the OPTAR accelerates (but does not initiate) the degradation of polymers that results from sunlight and other weathering effects (eg., rain, wind, ozone).

The OPTAR offers an important advantages over accelerated-aging chambers equipped with artificial light sources: firstly, it uses natural sunlight, which is real and more consistent than artificial sources and, secondly, heat is the only accelerated stress and is easily regulated. The method also provides exposure to natural environmental conditions, including dark periods (during which some other chemical reactions occur). Data obtained from these tests can be used with confidence to predict lifetimes under natural aging at ambient temperatures.

The OPTAR is built around an aluminum plate 1 m square and 1.27 cm thick. Silicone heaters that have a power density of 5 W/(in.)^2 [0.8 W/(cm)^2] are bonded to the underside of the plate by silicone adhesive. A sheet of stainless steel is bonded similarly to the top side. A J-type thermocouple placed in a well drilled 20 cm deep in the side of the plate measures the temperature and serves as part of a thermostatic control for the heaters. The assembly is mounted in a heavy, framed wooden enclosure so that only the stainless-steel face is exposed. The specimens are clamped flush on this surface, aged for specific intervals, then removed for determinations of their properties as a function of time and temperature.

Many chemical reactions are based on simple first-order kinetics, in which the logarithm of a property of interest is found to change linearly with time. Polymers frequently depart from this type of behavior and exhibit an induction period, after which a given property changes suddenly (for example, elongation at break). Predictions of natural aging from accelerated data may be determined by plotting the logarithm of the induction period against the reciprocal of the absolute temperature, in accordance with the Arrhenius relationship. It has been found that these plots are linear and may be extrapolated to ambient temperatures to obtain the polymer lifetime under actual service conditions.

This work was done by Edward F. Cuddihy and Paul B. Willis of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 1 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA's Resident Office-JPL [see page 18]. Refer to NPO-17524.

Error-Compensated Telescope

A small correcting mirror would be relatively inexpensive.

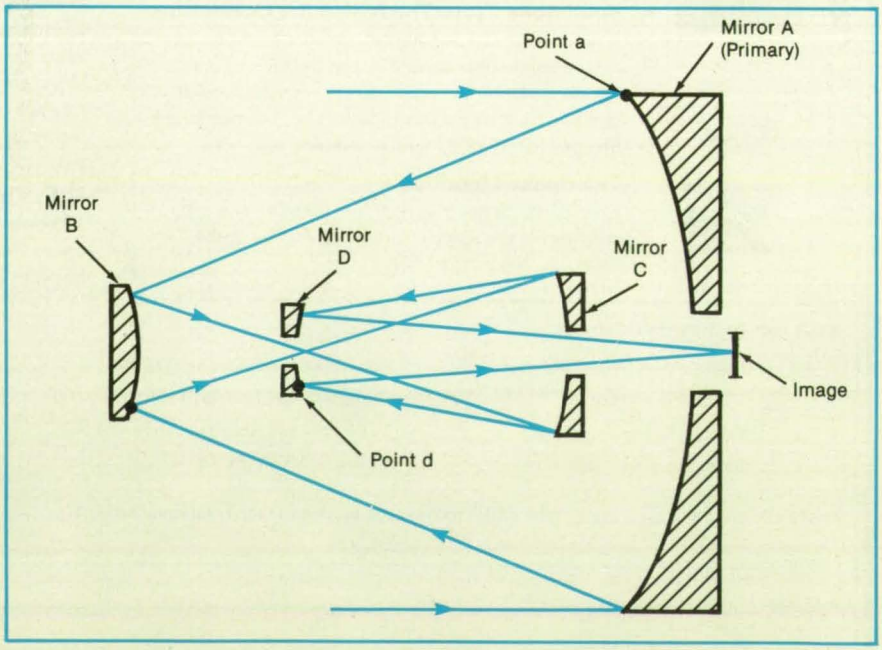
B89-10226

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed reflecting telescope would include a large, low-precision primary mirror stage and a small, precise correcting mirror. The correcting mirror would be machined under computer control to compensate for the error in the primary mirror. Because the second stage would be smaller, it would cost less to machine precisely and would maintain its shape more readily. Because the primary mirror would no longer have to be precise, it would no longer have to be made in one heavy piece to maintain its shape. Instead, it could be made of lightweight materials in deployable segments, without costly time-consuming polishing to final shape.

The correcting mirror would be machined by a diamond cutting tool. A computer would analyze interferometric measurements of the primary mirror to determine the shape of the surface of the correcting mirror needed to compensate for errors in the wave front reflected from the primary mirror and would command the position and movement of the cutting tool accordingly.

In a four-mirror version (see figure), mirror A is the primary mirror, the optical errors of which are to be corrected. Mirror B brings the light to an approximate focus in the hole in mirror D. Mirror C forms an exit pupil at mirror D, which is the error-correcting mirror. A tilt error at point *a* on mirror A can be corrected by a tilt at point *d* on mirror D so that the ray reflected from it ar-



Errors in the Wave Front Reflected From Mirror A would be corrected by compensating errors in the surface of mirror D. The corrections ensure that points in the image occupy the same relative positions in the image that they do in the field of view.

rives at the proper place in the image. Similarly, a piston error of a segment of mirror A can be compensated by a piston displacement of the corresponding part of mirror D.

This work was done by Aden B. Meinel, Marjorie P. Meinel, and John E. Stacy of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 26 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-16869.

Photovoltaic-Driven Multiple-Quantum-Well Modulator

B89-10227

The microstructure and composition are tailored for sensitivity to the modulating signal.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed high-performance spatial light modulator would consist of a multiple-quantum-well, strain-layer superlattice similar to the one described in the accompanying article, "Strain-Layer-Superlattice Light Modulator" (NPO-16915). However, this device differs from the other one in that it would operate in transmission rather than in resonant reflection and therefore would include only one stack of GaAs/InAs layers having a total thickness less than the penetration depth (1 to 2 μm) of the optical modulating signal.

The alternating composition and selective doping of the layers would produce multiple quantum wells separated by space-charge barriers formed by the depletion of the n-doped GaAs layers (see figure). The photocurrent generated in the GaAs layers by the modulating signal produces large changes of carrier density in the quantum wells. The carrier confinement and the low density of two-dimensional states in the quantum wells lead to large shifts in the absorption edge of the quantum wells (E_Q). Therefore, light is modulated by selecting its photon energy in the range over which E_Q shifts.

The integration and relaxation time is affected by tunneling through the space-charge barriers. The quantum tunneling characteristics would be adjusted in fabrication by control of the thicknesses and doping of the layers. For example, at a given n-doped GaAs layer thickness, the barrier-tunneling time can be increased (to achieve longer integration time) by concentrating the dopant near the middle of each layer.

Overall, the compositions and thicknesses of the layers would be chosen to enhance the effect of the modulating light beam on the modulated light beam. Thus, it is expected that the sensitivity to modulation will be high, even though the number of layers must be limited by the penetration depth.

This work was done by Joseph Maserjian of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 99 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
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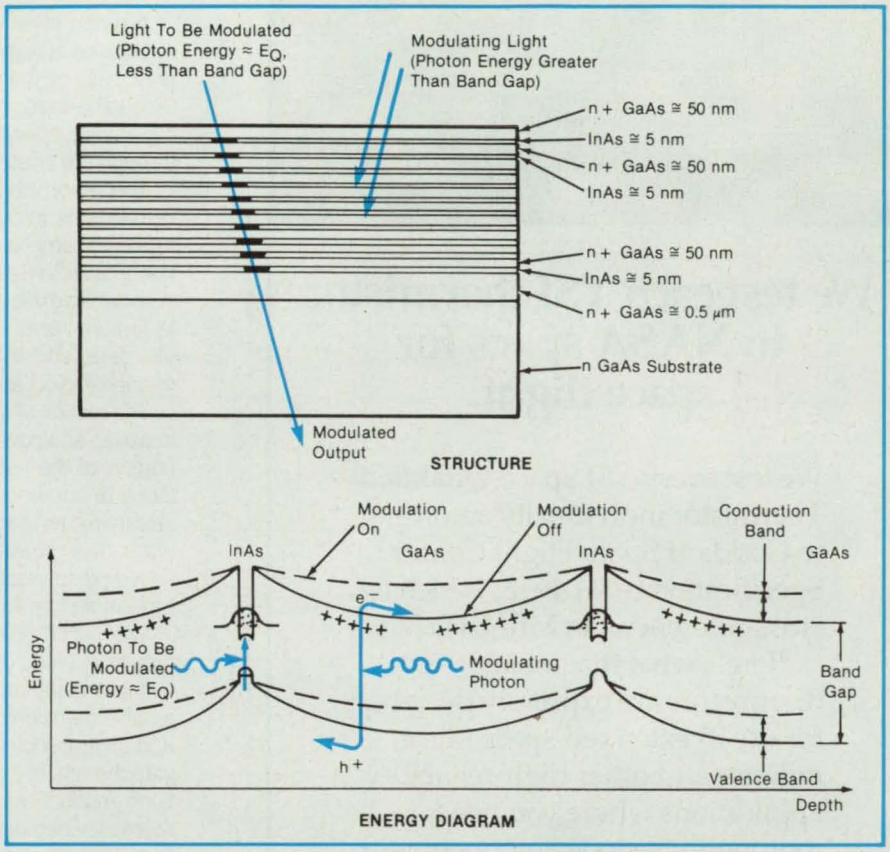
Refer to NPO-16914, volume and number of this NASA Tech Briefs *issue, and the page number.*



Alternating, Semitransparent Semiconductor Layers contain space-charge barriers that form quantum wells. The modulating light (with photon energy greater than the semiconductor band gap) induces photovoltaic action, which affects the transmission of the modulated light (having photon energy less than the band gap).

B89-10228

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

High-Altitude Turbulence for Supersonic Airplanes

Characteristics and associated meteorological features are discussed.

A report reviews the accumulated knowledge of atmospheric turbulence at high altitudes. This and related studies are motivated principally by the need to understand and predict the turbulence likely to be encountered by present and future airplanes cruising at supersonic speeds at altitudes ranging from the tropopause up through the stratosphere.

The report begins with a discussion of the characteristics of high-altitude turbulence and the associated meteorological features, with emphasis on data obtained by flight research conducted in XB-70 and YF-12A prototype aircraft. The intensity of turbulence is shown to exhibit predictable relationships with such atmospheric features and quantities as the wind-speed, the temperature structure, and a half dozen assorted parameters derived from meteorological and flight data.

The motion of gravity waves (meaning, in this case, atmospheric waves analogous to waves on the ocean) is involved in a major portion of the turbulence encountered at high altitudes. Turbulence at supersonic-cruise altitudes occurs in patches typically less than 1 km thick, thus suggesting that turbulence is generated in relatively shallow layers of atmospheric structure that are responding to excitation by waves of larger scale, in a manner reminiscent of the breaking of waves on the ocean.

The report gives an example of the numerical simulation of gravity waves to illustrate the potential contribution of such studies to the understanding of atmospheric turbulence. The relatively small dimensions of high-altitude turbulence patches and gusts and their association with underlying wave activity strongly motivate the use of numerical simulation to describe flows at resolutions much finer than are available from upper-air soundings. Moreover, because of the transient nature of waves breaking into turbulence, numerical simulation could potentially augment measurements taken by aircraft to interpret atmospheric structures in regions of strong turbulence.

Henceforth, progress will likely depend on advances in the numerical simulation of gravity waves and comparisons between simulations and observations. This may best be done by collaboration among experts in aircraft measurements, atmospheric observations, mesoscale analysis of the atmosphere, applied forecasting, theoretical atmospheric dynamics, and the formulation of mathematical models of gravity waves. The products of such efforts may include the ability to extend estimates of transient properties of the atmosphere at altitudes below 20 km to altitudes as high as 80 km for use in the design and flight simulation of future advanced aerospace vehicles. In addition, such efforts may enable a more accurate assessment of the feasibility of remote sensors and computer systems aboard airplanes to process measurements into advanced warnings of turbulence.

This work was done by L. J. Ehernberger of Dryden Flight Research Facility for **Ames Research Center**. *Furtherinformation may be found in NASA TM-88285 [N87-23100], "High Altitude Turbulence for Supersonic Cruise Vehicles."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12149

B89-10229

Research in Microgravity on Earth

Relatively economical and accessible facilities are described.

A report surveys ground-based facilities for research in microgravity. The report notes that because of the expense and limited opportunity of conducting research in orbit around the Earth, experiments on Earth must precede and accompany research in orbit. Programs based on the ground can sharpen the focus of space research and increase the benefits derived from it. In some cases, terrestrial research may eliminate the need for trials in orbit.

The ground-based facilities fall into three categories:

1. Those that provide a true microgravity environment for a short time, such as rockets, airplanes, drop towers, and drop tubes;
2. Those that emulate one or more aspects of the microgravity environment, such as electromagnetic or acoustic levitators; and
3. Those that aid in understanding behavior of systems in microgravity, such as model furnaces and computational facilities.

The report concentrates on material-processing facilities of NASA at Lewis Research Center, Marshall Space Flight Center, and the Jet Propulsion Laboratory. It describes the facilities briefly and provides names and telephone numbers of people who can give further information and arrange for qualified researchers to use the facilities.

This work was done by Bruce N. Rosenthal and Thomas K. Glasgow of **Lewis Research Center**, *Daniel D. Elleman of Caltech for NASA's Jet Propulsion Laboratory, and Richard E. Black of Marshall Space Flight Center. Further information may be found in NASA TM-88964 [N87-16917], "Research Opportunities in Microgravity Science and Applications During Shuttle Hiatus."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LEW-14660

Materials

Graphite Fluoride Fiber Composites for Heat Sinking

These electrically insulating materials are unusually thermally conductive.

Lewis Research Center, Cleveland, Ohio

B89 10230

Electrically-insulating engineering materials are generally also thermally insulating, and the latter property is a disadvantage in many electrical systems. This is because heat produced by the system is dissipated very slowly through the thermal insulator, resulting in an accumulation of waste energy and requiring an increase in the rejection temperature. Consequently, degradation of electrical performance may occur, and the life and reliability of the system may be compromised. This is especially true for state-of-the-art electrical systems, where higher power levels are being dissipated from smaller volumes.

Graphite fluoride fiber/polymer composite materials consist of graphite fluoride fibers in epoxy, polytetrafluoroethylene, or polyimide resin. They combine high electrical resistivity with high thermal conductivity and thus may solve the heat-transfer problems of many electrical systems. Possible applications include printed-circuit boards for high-density power electronics, insulators for magnetic-field cores like those found in alternators and transformers, substrates for thin-film resistors, and electrical-protection layers in aircraft deicers.

Graphite fluoride is commercially available in powder form, for use as a dry lubricant or cathode material in lithium batteries. It is produced by direct fluorination of graphite powder at a temperature of 400 to 650 °C. Direct fluorination of graphite fibers results in structural damage to the fibers and consequent reduction in the thermal conductivity of the fibers. Before fluorination, the major mechanism for heat conduction (i.e., the transmission of molecular vibrations via the carbon/carbon double bonds) is such that single crystals of graphite have four times the thermal conductivity of copper, and a high-modulus graphite fiber has a thermal conductivity comparable to that of copper at room temperature.

The damage to the fibers due to fluorination can be reduced by first intercalating the fibers with bromine or fluorine/metal fluoride. To some extent, the treated fibers can then react with fluorine at lower temperature and less reaction time, without suffering structural damage.

The thermal conductivities of graphite fluoride fibers produced in this manner ranged from 5 to 75 W/(m•K), compared to glass at 1.1 W/(m•K) and stainless steel at 15 W/(m•K). The electrical resistivities of these fibers ranged from 10^{-2} to larger than 10^{11} ohm•cm. The particular graphite fiber used, the preprocessing, and the fluorination temperature all affected the thermal conductivities of the final products.

This work was done by Ching-cheh Hung of **Lewis Research Center** *and Martin Long and Mark Stahl of Cleveland State University. Further information may be found in NASA TM-100156 [N87-26232/NSP], "Synthesis, Physical and Chemical Properties, and Potential Applications of Graphite Fluoride Fibers."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center [see page 18]. Refer to LEW-14472.

Growing Gallium Arsenide on Silicon

Epitaxial layers of high quality are formed on the <111> crystal plane.

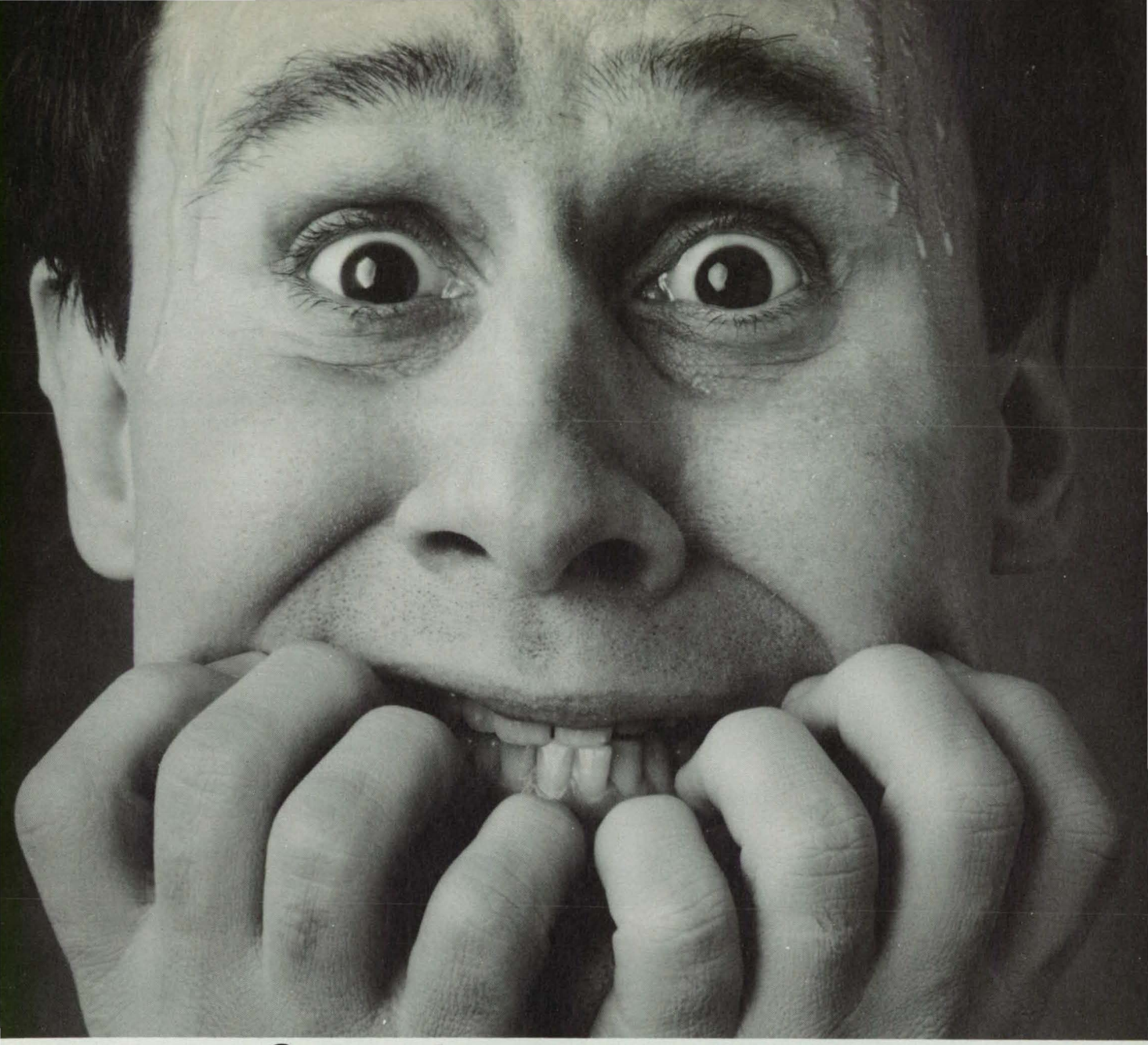
NASA's Jet Propulsion Laboratory, Pasadena, California

B89-10231

Almost all studies reported to date have employed Si<100> wafers as substrates for the fabrication of GaAs/AlGaAs lasers as well as other GaAs devices. The <100> orientation has been selected over others, a natural consequence of its compatability with the existing, well-established Si<100> VLSI (very-large-scale integration) technology. Insofar as growth of GaAs on Si crystal orientations other than <100> is concerned, very little information is available. One study investigated the molecular-beam epitaxy (MBE) growth of GaAs on Si<211> and also compared the growth of a 200-nm-thick GaAs layer on four different substrate orientations, namely Si<211>, <110>, <111>, and <100>. However, the growth on Si<111> was described as being discontinuous. Significant areas of the <111> wafers were found to exhibit no growth of GaAs on them, attributed to the difficulty of nucleation of GaAs on the Si<111> surface.

The present work reports successful growth of 1- and 2-μm thick layers of an n-type, 7-Ω•cm, 2-inch (5-cm) diameter, Si<111> substrate. The growth was conducted in the Riber-2300® MBE system. Both doped and undoped layers of GaAs were grown. The Si<111> substrates that were on axis (within ± ½ °) as well as off-axis toward the 110 axis were employed.

Following an initial degreasing step (trichloroethylene, acetone, and methanol), the Si<111> wafers were first boiled in a 1:1 nitric acid/sulfuric acid solution for 5 min, then chemically oxidized in a 1:1:5 mixture of hydrochloric acid, hydrogen peroxide, and water. The oxide was etched in a dilute hydrofluoric acid solution (10 percent). The sequence of chemical oxidation/oxide-removal was repeated three times. Finally, an oxide layer was grown, and the wafers were rinsed in deionized water and blown dry with N_2.



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The chemical oxide grown on Si by the above recipe was approximately 10 Å thick, as measured by photoelectron spectroscopy. Oxide-coated Si wafers were loaded into a N_2 load-lock chamber. They were then spin-etched with a 1:5 solution of hydrofluoric acid in ethanol to remove the oxide, before being transferred into the MBE growth chamber. Growth of GaAs on the Si<111> surface was initiated by a 4-s exposure to As at a substrate temperature of ~400 °C. With the surface primed by As, the Ga shutter was also opened, and GaAs was nucleated at the rate of 0.1 monolayer/s. The slow growth was continued for 10 min, which corresponded to 60 monolayers of GaAs. During this growth, the substrate temperature was gradually ramped up to ~580 °C, and, at this stage, faster growth was carried out continuously at the rate of 1 monolayer/s (1 μm/h).

The MBE growth chamber was equipped with an electron gun and camera for in-situ reflection high-energy-electron diffraction (RHEED) measurements. RHEED patterns of the surface were monitored continuously during the slow growth stage.

This work was done by Gouri Radhakrishnan of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 46 on the TSP Request Card.*
NPO-17360

Computing Viscoplastic Behavior of a Material

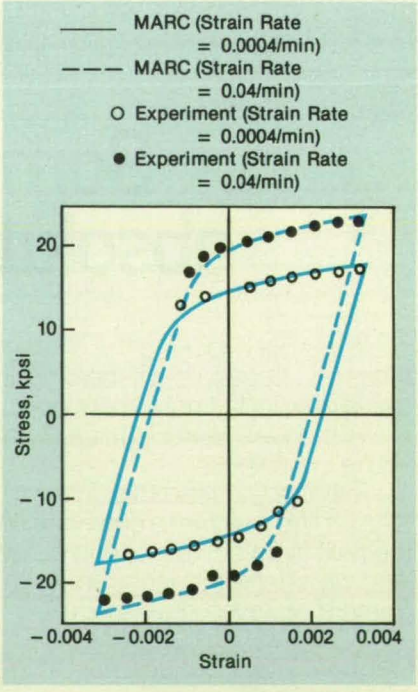
B89-10232

Robinson's model of viscoplasticity is implemented via a finite-element computer program.

Lewis Research Center, Cleveland, Ohio

A finite-element implementation has been developed for Robinson's unified model of viscoplasticity. The method can be used to calculate elastic, plastic, and creep deformations in solid materials at various temperatures; it can be used to study the thermomechanical behavior of such things as hot pressure vessels and highly stressed components in engines.

In Robinson's model, the flow and the evolution of internal variables of the material are derived from a flow potential. The behavior of the material is considered elastic in all states of stress within the flow potential and viscoplastic in all states of stress outside the flow potential. Assuming small displacements and strains, the total strain rate is taken as the sum of elastic and inelastic parts. The material is assumed to be isotropic, and the elastic component of the strain rate is assumed to be



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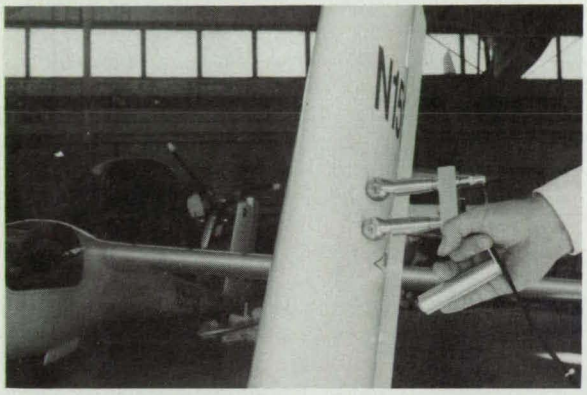

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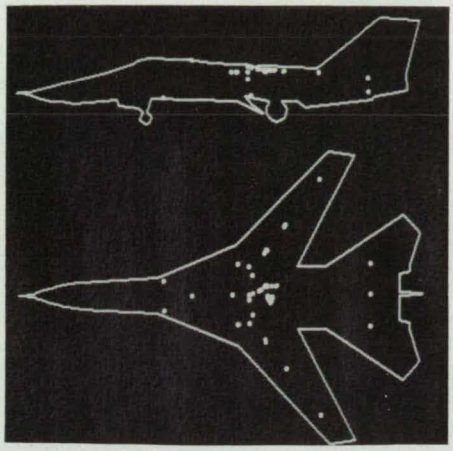

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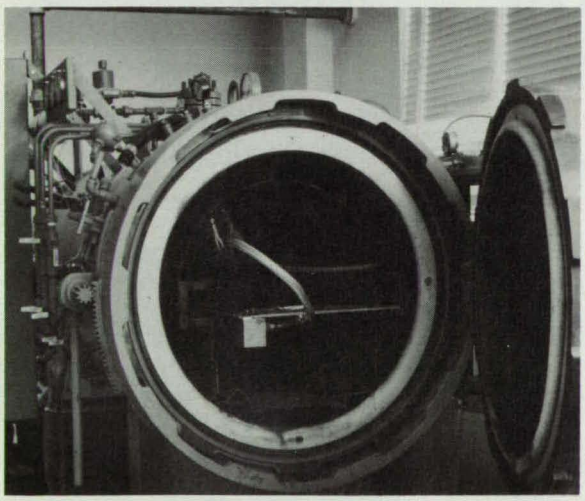

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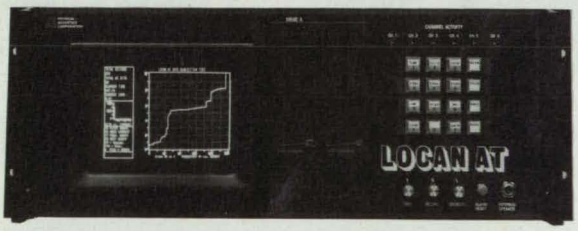

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The Integrated NDT People

Circle Reader Action No. 425

related to the stress rate via Hooke's law.

The growth of the internal state variable that accounts for kinematic hardening is based on the Bailey-Orowan theory, which includes the hardening effect of accumulated deformation and a recovery or softening effect that proceeds with time. The equation for flow expresses the relationships among the deviatoric stress, the hardening-state variable, and the inelastic component of the strain rate. The material parameters in the equations for the state variable and the flow are represented by simple temperature-dependent models.

Robinson's model is implemented via the MARC general-purpose finite-element computer program by incorporating all of the nonlinearity of the material into an initial load vector and treating the vector as a pseudo body force in finite-element equilibrium equations. Because the gradients of some of the quantities in the constitutive equations of the model are large, it is best to use a subincrement technique to form the incremental constitutive equations that correspond to a finite increment of load. In this technique, each finite increment is split into several equal subincrements, over each of which the constitutive equations are integrated by the explicit Euler forward-difference method. The HYPELA subroutine in MARC includes an adaptive integration scheme that selects optimal sizes of the subincrements. A spline function smooths discontinuous boundaries in Robinson's model to facilitate the finite-element numerical calculations.

The method was tested by using it to calculate the combined effects, on a steel alloy, of cyclic heating and cooling with both in-phase and opposite-phase cyclic uniaxial strain. The calculated stress-vs.-strain hysteresis loops agreed closely with those obtained in experiments (see figure). In another test, the method was applied to a hot thick-walled cylinder containing gas under pressure. In this case, experimental data were not available, but the results of the MARC calculations agreed well with those obtained from an explicit Euler forward integration of an exact integral representation of Robinson's model.

This work was done by V. K. Arya and A. Kaufman of **Lewis Research Center**. *Further information may be found in NASA TM-89891 [N87-23010], "Finite Element Implementation of Robinson's Unified Viscoplastic Model and Its Application to Some Uniaxial and Multiaxial Problems."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-14712

Shatter-Resistant, Flame-Resistant Window

Clear plastic and mineral sheets are joined.

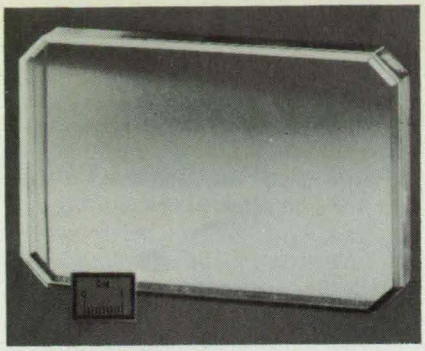
Lewis Research Center, Cleveland, Ohio

B89-10233

A combustion-chamber window combines the properties of polycarbonate and sapphire. The inner layer of sapphire, although brittle, withstands the flame in the chamber. The outer layer of polycarbonate is tough but susceptible to weakening by the flame and is protected from the flame by the sapphire layer. The result (see figure) is a window that resists flames, shattering, and high pressures.

The layers are bonded together by an adhesive to eliminate a gap between them, which would reduce the light transmitted through the window. With the gap eliminated, subtle combustion effects can be observed and photographed.

The surfaces of the layers are thoroughly cleaned before assembly. First ethyl alcohol, then ammonium hydroxide are applied with a cotton pad. Several applications of the solvents are necessary, and care must be taken to avoid scratching the polycarbonate. The cleaned surfaces are



The **Polycarbonate/Sapphire Sandwich** is a safe, reliable window for a pressurized or evacuated combustion chamber. The window is 2¾ in. high and 5¼ in. long (7 by 13.3 cm). The polycarbonate layer (toward the rear in this photograph) is one-half in. (12.7 mm) thick; the sapphire is substantially thinner.

exposed to a stream of ionized air to remove dust and static electricity.

About 15 drops of a commercial optical adhesive (Norland No. 68 or equivalent) are applied to the flattest side of the polycarbonate piece in a pattern to provide even coverage. When the adhesive has spread out evenly under its own weight, trapped air bubbles are removed. The sapphire plate is lowered onto the adhesive, and a weight is placed on the sapphire. After about half an hour, the adhesive layer spreads to the edges, and any remaining air bubbles are expelled along with excess adhesive.

The sapphire/adhesive/polycarbonate sandwich is exposed to long-wave ultraviolet light for 6 hours to cure the adhesive. A tent-shaped reflector over the ultraviolet lamp and the assembly concentrates the light.

The windows withstand 60 lb/in.^{2} (414 kPa) in a hydrostatic pressure vessel. They also survive a leak test under an internal pressure of 2 atm (0.2 MPa) of helium and external pressure of 10^{-5} torr (1.3 mPa). The windows have a transmission density of 0.08 to 0.11 in visible light. In contrast, the unbonded layers have a transmission density of 0.13 to 0.16.

This work was done by William R. Richardson and Ernie D. Walker of **Lewis Research Center**. *Further information may be found in NASA TM-100188 [N87-28880], "Bonding Lexan and Sapphire to Form High-Pressure, Flame-Resistant Window."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LEW-14743

Testing Bonds Between Brittle and Ductile Films

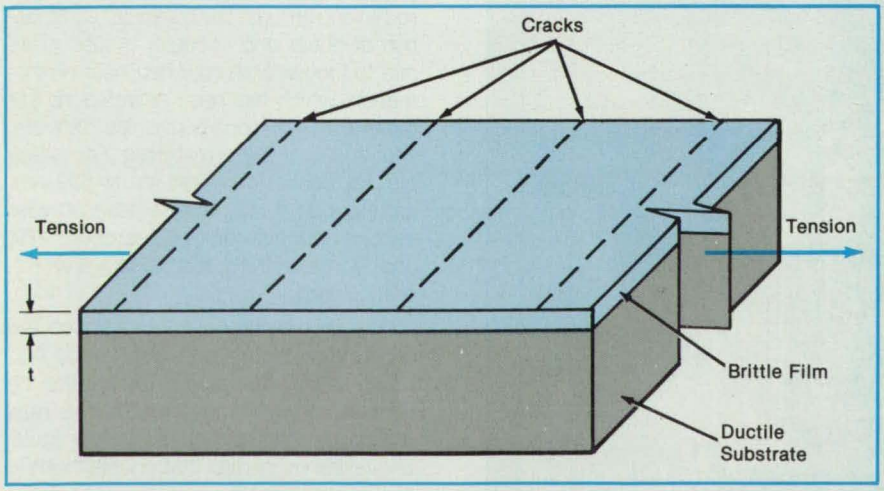
B89-10234

Simple measurements are interpreted through a simple theory.

Lewis Research Center, Cleveland, Ohio

A simple uniaxial strain test has been devised to measure the intrinsic shear strength, τ_0, of the bond between a relatively-ductile substrate film (specifically, polyethylene terephthalate) and a brittle film (iron, nickel, or cobalt) deposited on the substrate (see figure). The results of the test are interpreted by a simplified theory, which leads to a simple and approximate but reliable formula for τ_0 in terms of easily measured properties of the specimen.

A typical specimen could consist of a



A **Brittle Film Is Deposited on a Ductile Substrate Film**, and the combination is stretched until the brittle film cracks, then separates from the substrate. The dimensions of the cracked segments are related in a known way to the tensile strength of the brittle film and the shear strength of the bond between the two films.

strip of polyethylene terephthalate 6 or 12 μm thick, 2.5 mm wide, and 1.5 cm long, with a film of metal 0.2 to 1.2 μm thick and 3 mm long deposited near the midlength of the substrate. The specimen could be formed by evaporating metal onto the substrate while monitoring the thickness of the metal with a quartz-crystal thickness monitor. An ion gun could be used to treat the substrate before deposition, to modify the adhesion between the layers.

In the test, the specimen is stretched slowly. The metal film begins to show a pattern of cracks parallel to each other and perpendicular to the lengthwise strain — a pattern that is characteristic of brittle fracture. As the strain increases, cracking progresses through three distinct stages. In the first stage, the metal film cracks at random locations along its length. In the second stage, the metal segments between the first-stage cracks subdivide into smaller segments by cracking at their midpoints, the longest segment cracking first, followed by the second longest segment, and so on. In the third stage, the segments of metal film separate from the substrate at the cracks, the longest segment separating first. A further increase of strain causes the separation of successively shorter segments but no further cracking.

The approximate formula for the shear strength of the bond is

$$\tau_0 = 4\sigma_0 t/l_f$$

where σ_0 is the tensile strength of the metal film, t is the thickness of the metal film, and l_f is the length of the longest (and first) segment of metal film that separates.

For the purpose of the approximation, σ_0 is assumed to be independent of t and measurable by tensile tests of independent specimens. A more exact analysis would take account of the effect of thickness and the method of deposition. Depending on whether the substrate behaves fully elastically or fully plastically (instead of a combination of the two as assumed for the approximation), the multiplicative factor could increase beyond 4 or could decrease to as little as 2. The determination of a more-precise multiplicative factor would require a detailed, three-dimensional elastoplastic analysis of the specimen. Despite the approximations and limitations of this technique, tests show that it yields semiquantitative measures of bond strengths, independent of the mechanical properties of the substrates, with results reproducible within ±6 percent.

This work was done by Donald R. Wheeler of **Lewis Research Center** *and Hiroyuki Ohsaki of Sony Magnetic Products, Inc. For further information, Circle 33 on the TSP Request Card.*
LEW-14750

Diphenylpolyynes for Nonlinear Optical Devices

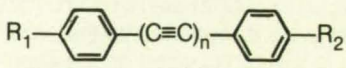
B89-10235

Donor/acceptor molecules have second-order nonlinear electric susceptibilities.

NASA's Jet Propulsion Laboratory, Pasadena, California

Several diphenylpolyyne compounds have been found to exhibit second-order nonlinear electric susceptibilities and chemical structures conducive to orientation in appropriate chemical environments. These features make the new materials suitable for use in optical devices.

The molecules that have been synthesized are shown in the table below: Asymmetric Substituted Diphenylacetylenes



No.	R_1	R_2	n
1	NH_2—	—NO_2	1
2	NH_2—	—NO_2	2
3	NH_2—	—NO_2	3
4	CH_3S—	—NO_2	1
5	CH_3S—	—NO_2	2
6	NH_2—	—CN	1
7	NH_2—	—CN	2
8	CH_3S—	—CN	1
9	CH_3S—	—CN	2
10	NH_2—	—CO_2CH_3	1
11	NH_2—	—CO_2CH_3	2

The important feature of these molecules is the presence of electron-donor functional groups (the R_1 groups shown on the left) and electron-acceptor functional groups (R_2) separated by conjugated rigid-rod linking groups. The particular combination of donor and acceptor groups gives rise to the second-order nonlinear phenomenon, which has been detected via the generation of second harmonics in several specimens of these materials. For example, for converting 1064 nm to 532 nm, compounds 4, 10, and 11 have powder second-harmonic efficiencies of 65, 120, and 17, respectively, relative to a urea reference sample.

The diphenylacetylene links give the molecules rodlike characteristics that make them amenable to orientation by suspension in liquid crystals. The new molecules may also have inherent liquid-crystalline properties that enable them to be oriented directly.

This work was done by Albert E. Stiegman, Joseph W. Perry, and Daniel R. Coulter of Caltech for **NASA's Jet Propulsion Lab-**

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oratory. *For further information, Circle 35 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA's Resident Office-JPL [see page 18]. Refer to NPO-17572

Surface Halogenation of High-Temperature Superconductors

Nonaqueous chemical etching and passivation yield improved surfaces.

B89-10236

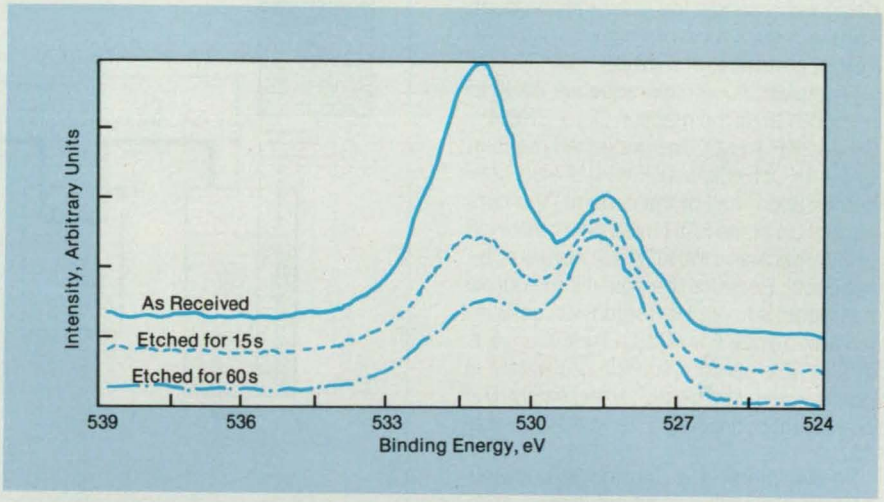
NASA's Jet Propulsion Laboratory, Pasadena, California

Surface halogenation is an experimental technique of postgrowth nonaqueous chemical processing of high-temperature superconductors. Research continues in the use of this technique to obtain superconducting and/or passivated surfaces, to etch bulk superconductors, and to make low-resistance electrical contacts.

The new high-temperature superconductors like $YBa_2Cu_3O_{7-x}$, $(La_{1-x}M_x)_2CuO_{4-y}$ (where M = Ba, Sr, or Ca; $x \lesssim 0.2$; and $y \lesssim 0.1$), and others do not have superconducting surfaces when grown by current methods. Annealing procedures can produce nonsuperconducting surface regions, the chemical compositions of which differ from those of the bulk materials. In addition, these materials react with atmospheric H_2O and CO_2 to form insulating hydroxides and carbonates at the grain boundaries and on the surfaces. Consequently aqueous etching and ion milling (which reduces the Cu) are not suitable.

The most promising etchant appears to be bromine dissolved in such polar nonaqueous solvents as alcohols, acetone, or ether. In one series of experiments, a solution of 1 volume percent bromine in absolute ethanol was used to etch films of $YBa_2Cu_3O_{7-x}$. The formation of the bromides of Y, Ba, and Cu was verified by x-ray photoelectron spectroscopy (XPS) on unrinsed specimens. Rinsing in absolute ethanol removed most of the bromides, but about 2 atomic percent bromine remained on the rinsed surfaces. The 531.1-eV peak in the XPS spectrum of oxygen, which is characteristic of surface contaminants, was reduced to near a minimum intensity after 15 to 30 s of etching, with little further reduction after longer etches. The final spectrum shown in the figure compares favorably with the published spectra of samples scraped in a vacuum. (Scraping in a vacuum is the best conventional surface-cleaning technique, but it requires much care and is not practical for production.)

Measurements of resistance vs. temperature showed that a 1-μm-thick film etched for 30 seconds had zero resistance at 78 K, while a similar unetched film, grown and annealed at the same time, had zero resistance at 81 K, which is within the sample-to-sample variability. Thus, the etchant appears to act only on the surface without adversely affecting the superconducting bulk of the film. In addition, preliminary results show that the surface resistance of Pb contacts evaporated onto an etched film is $< 600\ \mu\Omega\cdot cm^2$ at room temperature and $< 150\ \mu\Omega\cdot cm^2$ at the temperature of liquid helium, two orders of magnitude less than the surface resis-



The **X-Ray Photoelectron Spectrum** of the 1s level of oxygen shows the effect of etching by 1 percent bromine in absolute ethanol. The diminution of the peak at 531.1 eV indicates the removal of surface contaminants.

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tance measured on an unetched film.

This work was done by Richard P. Vasquez of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 142 on the TSP Request Card.* NPO-17712

Pilot Plant Makes Oxygen Difluoride

B89-10237

Equipment processes the toxic, difficult-to-make substance efficiently and safely.

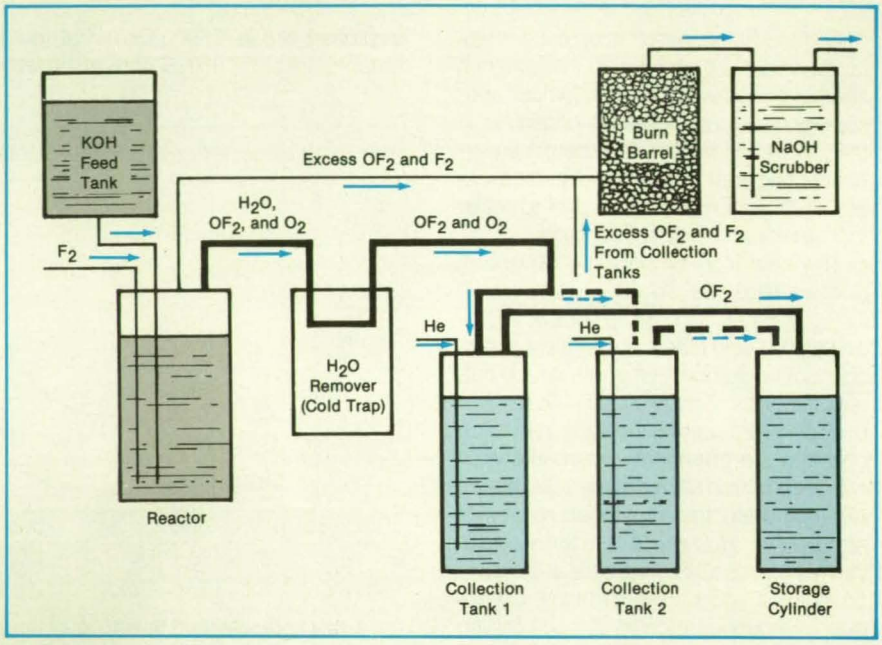
NASA's Jet Propulsion Laboratory, Pasadena, California

A pilot plant makes oxygen difluoride, a highly-energetic, space-storable oxidizer that is not made commercially. The plant is designed to handle the reactants, product, and byproduct, most of which are highly reactive, corrosive, and toxic.

The plant fluorinates aqueous alkali to produce OF_2 in the reaction $2F_2 + 2KOH \rightarrow OF_2 + 2KF + H_2O$. The undesired reaction $2F_2 + 4KOH \rightarrow O_2 + 4KF + H_2O$ also consumes about half of the fluorine. The concentration of the KOH must be maintained at 2 percent, and the KOH solution must be kept cold. Because the potassium fluoride byproduct is toxic, it is treated with calcium hydroxide: $2KF + Ca(OH)_2 \rightarrow CaF_2\downarrow + 2KOH$. The calcium fluoride precipitate is nontoxic and can be discarded safely. The potassium hydroxide is recycled to the solution.

In the plant, the fluorine is bubbled through the chilled KOH solution in a reactor (see figure). The OF_2 and the O_2 from the competing reaction are passed through a cold trap to remove water. Another cold trap (not shown) also removes carbon dioxide, which is present as an impurity. The OF_2 and O_2 are then condensed in a collection tank. When a sensor indicates that the tank is filled nearly to capacity, that tank is disconnected and collection resumes in a second tank. The first tank is sparged with helium, which vaporizes the C_2 and leaves the OF_2 behind. The OF_2 is transferred to cylinders for storage.

Waste OF_2 and F_2 are sent to a stainless-steel barrel lined with ceramic insulation and filled with wood charcoal. In a spontaneous reaction, the charcoal burns in the toxic waste oxidizers. To prevent the escape of toxic gases, the barrel is vented through another drum filled with a dilute solution of NaOH.



Oxygen Difluoride Evolves Continuously from a reactor that contains potassium hydroxide in water at 0°C. The collection tanks are alternated; one is filled while the other is drained to a storage cylinder. Excess OF_2 and F_2 are dissipated in the combustion of charcoal in a burn barrel. The toxic byproduct, potassium fluoride, is reacted with calcium hydroxide to form the nontoxic calcium fluoride and to regenerate the potassium hydroxide.

The plant is constructed of stainless steel that has been passivated with fluorine gas. The valves have copper seats rather than plastic ones, which would react with the oxidizers. The plant is located in a test bay and is controlled from a remote console. Video cameras monitor the reactors. Microcoulombic sensors, in which traces of oxidant create a current proportional to the concentration, continuously check the test bay for leakage. The sensors can detect concentrations as low as 0.05 part per million, well below the maximum allowable concentration for humans. They respond rapidly, well before a human can detect the strong odor of OF_2.

The pilot plant consumes about 1 lb (0.45 kg) of fluorine per hour. It produces 0.38 to 5.0 lb (0.17 to 2.3 kg) of OF_2 per hour.

This work was done by Marshall F. Humphrey and Emil A. Lawton of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 43 on the TSP Request Card.* NPO-17347

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Design and Fabrication of Superconductors

Progress through 1982 is reviewed.

B89-10238

A report reviews selected aspects of the technology of superconductors, reflecting the progress of recent decades ending in the year 1982. In particular, it provides a fairly comprehensive discussion of the design and fabrication of conventionally and unconventionally processed composite superconductors made of alloys based on Ti/Nb and on A15 compounds (Nb_3Sn, V_3Ga, and others).

In the terminology of the report, "conventional" processes are those that involve the heating of wires drawn from packed mixtures of reactant metal powders, the deposition and heating of reactant metal powders on inert metal-tape substrates, and the Cu/V_3Ga and Cu/Nb_3Sn "bronze" processes, in which filaments of V or Nb embedded in Cu/Ga or Sn bronze matrices are heat-treated to convert them to, or encrust them with, A15 compounds. The "unconventional" processes include chemical-vapor deposition or sputtering (used with Nb_3Ge), direct reactions between the elements (used with Nb_3Al), and modified "bronze" processes that incorporate these techniques.

The first two sections of the report introduce the general properties of alloy and compound superconductors and the requirements on design and processing for the production of long pieces of stable, low-loss conductor. Section 3 deals with all aspects of flux-jump stability and the general requirements of cryogenic stabilization.

Section 4 discusses the design of con-

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ductors with respect to ac power losses. Some basic formulas describing hysteretic and eddy-current losses are presented, and the influences of the diameters of filaments and strands, the twist pitch, and the electrical resistivity of the matrix are discussed.

Section 5 describes the basic techniques used in the fabrication of conventional multifilamentary conductors. This description is generic and applicable to the pre-heat-treatment phases of the fabrication of both alloy and compound conductors.

Section 6 considers conventional Ti/Nb-base composite conductors. Commencing with a brief description of metaequilibrium and equilibrium Ti/Nb phases, the metallurgical prerequisites for high current-carrying capacity are discussed. With this as a foundation, the section goes on to consider the optimization of alloy superconductors via adjustments of the thermomechanical processes used to make them and the advances that have recently been made toward the development of high-performance Ti/Nb-base alloy superconductors.

Section 7 discusses early and unconventional titanium-alloy superconductors. It refers to a method for continuously coating a superconducting wire or tape with a stabilizing layer of some simple or noble metal, "*in situ*" processing of composite conductors by directional solidification, and a powder-metallurgical technique.

Section 8 deals briefly with the conventional processing of A15 conductors; that is, the use of bronze-process chemistry in association with fabricated-billet metalworking. Emphasis is placed on the various ways in which Sn can be introduced to the Nb, process control of flux-pinning strength, and the effect of multicomponent alloying on the superconducting properties.

Section 9 describes several unconventional processes used to make A15 superconductors. It discusses the optimization of flux pinning and critical current in both powder-metallurgically and "*in situ*" processed conductors through the addition of metallic elements either internally or externally and through the control of the sizes of fibers and reaction-layer grains. The extents to which the critical current densities of conventionally and unconventionally processed conductors respond to stress or strain are compared. This section concludes with a discussion of ac losses. The review is illustrated with 44 line drawings and 29 photographs and lists 245 references.

This work was done by E. W. Collings of Battelle Memorial Institute for **Marshall Space Flight Center**. *To obtain a copy of the report, "Design and Fabrication of Conventional and Unconventional Superconductors," Circle 95 on the TSP Request Card.*
MFS-27029

B89-10239

Improving Silicon Carbide/Silicon Nitride Fibers

Strengths might be increased through modifications in the monomeric precursors.

Experiments described in a report indicate that the properties of silicon carbide/silicon nitride fibers may change significantly with modifications of the monomeric precursors. This allows the possibility of creating improved silicon carbide/silicon nitride fibers, which could replace graphite fibers in composite materials requiring high electrical resistance and thermal stability.

In the preparation of silicon carbide/silicon nitride fibers, tris (alkyl- or arylamino)silanes are prepared by the dropwise addition of methyl or phenyl trichlorosilane to a solution of the alkyl or aryl amine in toluene or petroleum ether at a low temperature under dry nitrogen. After addition is complete, the solution is refluxed for one hour. The mixture is then filtered to remove salt produced during the reaction, and the product is purified by distillation at reduced pressure.

The monomers are polymerized by heating to temperatures above 500 °C. Fibers are drawn from a resin melt under a stream of dry nitrogen, cured in an environmental chamber at 100 °C and 95 percent relative

humidity until unmeltable, then placed under tension and pyrolyzed at 1,200 to 1,500 °C to produce the inorganic silicon carbide/silicon nitride fibers.

Silicon carbide/silicon nitride fibers made from the tris (N-methylamino)methylsilane (TMMS) monomer have a tensile modulus of approximately 29 × 10^6 psi (2.0 × 10^{11} N/m^2). At this stage of development, the modulus compares favorably with the average value of 55 × 10^6 psi (3.8 × 10^{11} N/m^2) for graphite fibers. The electrical resistivity of the silicon carbide/silicon nitride fibers, 7 × 10^8 ohm-cm, lies in the semiconductor range, but approaches the value of a true insulator (≥10^{12} ohm-cm).

Although fibers formed from TMMS thus show great potential, further development is required. Structural modification of the monomer might lead to polycarbosilazanes exhibiting lower pyrolytic mass loss and shrinkage and, hence, fewer fiber defects in the resulting silicon carbide/silicon nitride fibers. Attempted polymerization of tris (anilino)methylsilane (TAMS) and tris (N-propylamino)methylsilane (TPMS) monomers has failed to yield a resin suitable for fiber formation, perhaps because optimal polymerization conditions have not yet been determined. Although these preliminary findings suggest that monomers with larger alkyl groups will alter the properties of the silicon carbide/silicon nitride fiber precursors disadvantageously, considerable work remains before rigid conclusions can be drawn. Indications are that fiber properties will change significantly with minor structural modifications in the monomer, but only when a large number of pure polymers are available will these properties be finely tuned. Perhaps copolymers or blends of several polycarbosilazanes will yield the best silicon carbide/silicon nitride fibers.

This work was done by David J. Crouse and Benjamin G. Penn of Tennessee Technological University for **Marshall Space Flight Center.** *To obtain a copy of the report, "Silicon Carbide-Silicon Nitride Fibers: Preparation and Characterization of Polycarbosilazane Precursors," Circle 94 on the TSP Request Card.*
MFS-27101

B89-10240

Study of Phase Separation in Glass

The effect of the hydroxide content is examined.

A report describes an experimental study of the effect of the hydroxide content on phase separation in soda/silica glasses. Studies like this one may eventually help material scientists to find ways to control the morphology of phase separation, which is desirable because it is instrumental in determining the physical and mechanical properties of glasses.

Ordinary and gel glasses were melted at 1,565 °C, and the melts were stirred periodically. "Wet" glasses were produced by passing bubbles of N_2 saturated with water through the melts; "dry" glasses were prepared in a similar manner, except that the N_2 was dried before passage through the melts.

Atomic absorption was used to analyze trace impurities in the glasses. Analyses of the compositions of the glasses were performed by atomic-absorption and index-of-refraction measurements. The hydroxyl contents of the glasses were measured by the absorption of infrared radiation.

Samples of each glass were heated to 590 °C and held at that temperature for various intervals to promote phase separation. The samples were then examined by small-angle x-ray scattering: the intensity of the scattered x-radiation as a function of the scattering angle depends on, and can be interpreted in terms of, the nature, sizes, and distribution of the phase-separated regions or particles that cause the scattering.

The x-ray scattering data had features that would be expected in scattering by particles of a minor phase. Replication electron micrographs that were made of selected samples confirmed the particle-like nature of the minor phase and appeared to indicate that the particles were approximately spherical. The scattering data from samples heated for longer times indicated that the larger particles continued to grow, while the smaller ones tended to disappear. This suggests that the particle-size distribution changes via an Ostwald coarsening process rather than by simple diffusion-controlled growth.

The rates of growth deduced from the scattering data were greater in the glasses that contained more water. There were minor differences between growth in the gel and in the ordinary glasses, but these may be due to slight differences in composition. Thus, the authors conclude that hydroxide speeds up phase separation, regardless of the method (gel or ordinary) by which the glass was prepared.

The authors of a previous study had concluded that the primary effect of the hydroxide was to hasten the nucleation (rather than the growth). This study yielded no information on nucleation rates; such information would have to be obtained from further studies of the early stage of phase separation.

This work was done by George F. Neilson, Michael C. Weinberg, and Gary L. Smith of Caltech for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "Effect of Hydroxide Content on Phase Separation Behavior of Soda-Silica Glasses," Circle 108 on the TSP Request Card.*
NPO-16796

B89-10241

Effects of Twist on Ceramic Threads

Twist sometimes does and sometimes does not increase strength.

A report describes a study of the effects of yarn twist and other manufacturing parameters on the strength of ceramic sewing threads. Such threads are used to stitch insulating blankets for reusable spacecraft; they must resist the high temperatures and high aerodynamic loads of reentry into the atmosphere of the Earth.

Three types of thread were considered: silica, aluminoborosilicate (ABS) with 14 percent boria, and ABS with 2 percent boria. To make the silica thread, eight silica yarns with a silane finish were twisted into four pairs, and the four pairs were twisted together. Each of the ABS threads was made from four ABS yarns and a rayon service yarn. All of the ABS threads were coated with a copolymer sizing to enhance lubricity. The threads were made with various twists ranging from 59 to 394 turns per meter. They were tested for strength at temperatures ranging from 23 to 1,200 °C.

For silica thread, the best twist was found to be 300 turns per meter. This twist produced the highest break strength at temperatures up to about 540 °C, at and beyond which heat destroys the silane finish. At 1,200 °C, the strengthening effects of twist are nullified by annealing of the silica.

The overall strengths of both ABS threads are higher than that of the silica thread. For both ABS threads, the break strengths decrease with increasing twist up to 600 °C, at which temperature both the copolymer sizing and rayon service yarn are removed. This loss of strength is due to the breakage of yarns during fabrication as higher loads are placed on the yarns by increased twist.

The differences between the behaviors of the silica and ABS threads can be attributed in part to the combined effects of the sizing and of the service yarn in the ABS threads. Apparently, the sizing acts as a sheath that holds the twisted thread tightly together, minimizing the slippage of yarns during tensile loading. Above 600 °C, the strength of the ABS threads is no longer controlled by twist, sizing, or service yarn, but by thermally-induced compositional and structural changes in the ABS fibers.

The 2-percent-boria ABS thread has the highest strength at all temperatures. As the temperature rises from ambient to 600 °C, the sizing and service yarn burn off, with a consequent reduction in the strengths of all the threads. Regardless of twist, at 1,200 °C the silica thread retains only about 25 percent of its original strength, while the low- and high-boria ABS threads retain about 45 and 14 percent, respectively.

This work was done by Paul M. Sawko of **Ames Research Center** *and Huy Kim Tran of San Jose State University. To obtain a copy of the report, "Influence of Thread Construction on Strength of Ceramic Sewing Threads," Circle 149 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center [see page 18]. Refer to ARC-11849

Computer Programs

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Electronic Systems

B89-10242

Program for a Pushbutton Display

Light-emitting-diode displays on pushbuttons are controlled interactively.

The Programmable Display Pushbutton (PDP) is a pushbutton device available from Micro Switch that has a programmable 16 × 35 matrix of light-emitting diodes on the pushbutton surface. Any desired legends can be displayed on the PDP's, producing user-friendly applications that greatly reduce the need for dedicated manual controls. Because the PDP can interact with the operator, it can call for the correct response before transmitting its next message. It is both a simple manual control and a sophisticated programmable link between the operator and the host system.

The Programmable Display Pushbutton Legend Editor (PDPE) computer program is used to create the light-emitting-diode (LED) displays for the pushbuttons. PDPE encodes PDP control commands and legend data into message byte strings sent to a logic-refresh-and-control unit (LRCU). The LRCU serves as the driver for a set of four PDP's. The legend editor (PDPE) transmits to the LRCU commands specified by the user to control what is displayed on the LED faces of the individual pushbuttons. Upon receiving a command, the LRCU transmits an acknowledgement that the message was received and executed successfully. The user then observes the effect of the command on the PDP displays and decides whether or not to send the byte code of the message to a data file so that it can be called by an application program.

The PDPE program is written in FORTRAN for interactive execution. It was developed on a DEC VAX 11/780 computer under VMS. It has a central-memory requirement of approximately 12,800 bytes. It requires four Micro Switch PDP's and two RS-232 VAX 11/780 terminal ports. The PDPE program was developed in 1985.

This program was written by Anthony M. Busquets and William S. Luck, Jr., of **Langley Research Center**. *For further information, Circle 47 on the TSP Request Card. LAR-13671*

Mathematics and Information Sciences

Calculating Cumulative Binomial-Distribution Probabilities

B89-10243

Reliabilities and availabilities of *k*-out-of-*n* systems can be analyzed.

The cumulative-binomial computer program, CUMBIN, is one of a set of three programs that calculate cumulative binomial probability distributions for arbitrary inputs. The three programs, CUMBIN, NEWTONP (NPO-17556), and CROSSER (NPO-17557), can be used independently of one another. CUMBIN can be used by statisticians and users of statistical procedures, test plan-

ners, designers, and numerical analysts. The program has been used for calculations of reliability and availability.

CUMBIN calculates the probability that in a system of n components, at least k will be operating if the probability that any one is operating is p and the components are independent. Equivalently, this is the reliability of a k-out-of-n system having independent components with common reliability p. CUMBIN can be used to evaluate the incomplete beta distribution for two positive integer arguments. CUMBIN can also be used to evaluate the negative binomial distribution and the cumulative F distribution with both degrees of freedom even and to determine the size of the sample in designing a test.

CUMBIN is designed to work well with all integer values $0<k\leqslant n$ and $0<p<1$. To run the program, the user simply runs the executable version and inserts the information requested by the program. The program is not designed to reject incorrect inputs, so the user must take care to make sure the inputs are correct. Once all input data have been entered, the program calculates and lists the result.

The CUMBIN program is written in C. It was developed on an IBM AT computer with a numeric coprocessor using Microsoft C 5.0. Because the source code is written by use of standard C structures and functions, it should compile correctly with most C compilers. The format of the program is interactive. It has been implemented under DOS 3.2 and has a memory requirement of 26K. CUMBIN was developed in 1988.

This program was written by Ernest M. Scheuer and Paul N. Bowerman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 74 on the TSP Request Card.*
NPO-17555

System-Reliability Cumulative-Binomial Program

B89-10244

This program finds the probability required to yield a given system reliability.

The cumulative-binomial computer program, NEWTONP, is one of a set of three programs that calculate cumulative binomial probability distributions for arbitrary inputs. The three programs, NEWTONP, CUMBIN (NPO-17555), and CROSSER (NPO-17557), can be used independently of one another. NEWTONP can be used by statisticians and users of statistical procedures, test planners, designers, and numerical analysts. The program has been used for calculations of reliability and availability.

NEWTONP calculates the probability p required to yield a given system reliability V for a k-out-of-n system. It can also be used to determine the Clopper-Pearson confidence limits (either one-sided or two-sided) for the parameter p of a Bernoulli distribution. NEWTONP can also be used to determine Bayesian probability limits for a proportion (if the beta prior has positive integer parameters), the percentiles of incomplete beta distributions with positive integer parameters, the percentiles of F distributions in which both degrees of freedom are even, and the median plotting positions in probability plotting.

NEWTONP is designed to work well with all integer values $0<k\leqslant n$ and $0\leqslant V\leqslant 1$. To run the program, the user simply runs the executable version and inserts the information requested by the program. NEWTONP is not designed to reject incorrect inputs, so the user must take care to make sure that the inputs are correct. Once all input data have been entered, the program calculates and lists the result. It also lists the number of iterations of Newton's method required to calculate the answer within a given error.

The NEWTONP program is written in C. It was developed on an IBM AT computer with a numeric coprocessor using Microsoft C 5.0. Because the source code is written by use of standard C structures and functions, it should compile correctly with most C compilers. The format of the program is interactive. It has been implemented under DOS 3.2 and has a memory requirement of 26K. NEWTONP was developed in 1988.

This program was written by Ernest M. Scheuer and Paul N. Bowerman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 13 on the TSP Request Card.*
NPO-17556

B89-10245

Common-Reliability Cumulative-Binomial Program

The point of equality between the reliability of the system and the common reliability of the components is found.

The cumulative-binomial computer program, CROSSER, is one of a set of three programs that calculate cumulative binomial probability distributions for arbitrary inputs. The three programs, CROSSER, CUMBIN (NPO-17555), and NEWTONP (NPO-17556), can be used independently of one another. CROSSER can be used by statisticians and users of statistical procedures, test planners, designers, and numerical analysts. The program has been used for calculations of reliability and availability.

CROSSER calculates the point at which the reliability of a k-out-of-n system equals the common reliability of the n components. It is designed to work well with all in-

teger values $0<k<n$. To run the program, the user simply runs the executable version and inserts the information requested by the program. The program is not designed to reject incorrect inputs, so the user must take care to make sure that the inputs are correct. Once all input data have been entered, the program calculates and lists the result. It also lists the number of iterations of Newton's method required to calculate the answer within a given error.

The CROSSER program is written in C. It was developed on an IBM AT computer with a numeric coprocessor using Microsoft C 5.0. Because the source code is written by use of standard C structures and functions, it should compile correctly with most C compilers. The format of the program is interactive. It has been implemented under DOS 3.2 and has a memory requirement of 26K. CROSSER was developed in 1988.

This program was written by Ernest M. Scheuer and Paul N. Bowerman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 14 on the TSP Request Card.*
NPO-17557

B89-10246

Line-Editor Computer Program

Powerful editing tools are provided.

The ZED editing program for the DEC VAX computer is a simple, yet powerful line editor for text, program source code, and nonbinary data. Line editors can be superior to screen editors in some cases; for example, executing complex multiple or conditional commands or editing via slow modem lines. ZED excels in the processing of text by use of procedure files. For example, such procedures can reformat a file of addresses or remove all in-line comments from a FORTRAN program.

In addition to command files, ZED also features versatile search qualifiers, global changes, conditionals, online help, hexadecimal mode, space compression, looping, logical combinations of search strings, journaling, visible control characters, and automatic detabbing.

The ZED editor was originally developed at Cambridge University in London and has been repeatedly enhanced since 1976. Users of the Cambridge implementation have devised such elaborate ZED procedures as chess games, calculators, and programs for evaluating π. This implementation of ZED maintains almost all the characteristics of the Cambridge editor.

A complete ZED manual is included on the tape. ZED is written entirely in C for either batch or interactive execution on the DEC VAX computer under VMS 4.X and requires 80,896 bytes of memory. The program was released in 1988.

This program was written by Peter J. Scott of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 63 on the TSP Request Card.*
NPO-17300

Examining the Subroutine Structure of a VAX Image

A command program analyzes executable components of another program.

B89-10247

SCANEXE is a command program for the DEC VAX computer used to scan a VMS run-time image and print information about the routines it uses. Optionally, SCANEXE lists each routine, with its entry point, and how many times it is called, if at all. Information on the progress of the program can be printed at the user's option as it analyzes the various executable components.

SCANEXE relies on "debug" records that are included by default in ".EXE" files. However, if an image is linked with the "/NOTRACEBACK" option (as are all system programs), then it cannot provide the necessary information. SCANEXE counts only the number of times it finds a statement calling each routine, which is not necessarily the same as the number of times that the routine would be called if the

program were run.

SCANEXE is written in C (83 percent), FORTRAN 77 (13 percent), and Assembler (4 percent) for batch execution on the DEC VAX computer under VMS 4.X. It has a central-memory requirement of 61,952 bytes. The program was released in 1988.

This program was written by Peter J. Scott of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 62 on the TSP Request Card.*
NPO-17298

B89-10248

Medical-Information-Management System

Other alphabetical and/or numerical data (e.g., business or judicial) can also be managed.

The Medical Information Management System (MIMS) computer program is an interactive, general-purpose software system for the storage and retrieval of information. It was first designed to be used in the management of medical data and can be used to handle all aspects of data related to the care of patients. Other applications of MIMS include management of data on occupational safety in the public and private sectors, handling judicial information where speed and accuracy are high priorities, systemizing purchasing and procurement systems, and analyses of the cost structures of organizations.

Because of its free-format design, MIMS can offer immediate assistance where manipulation of large data bases is required. Structures of files, categories of data, and lengths and formats of files, including alphabetical and/or numerical, are all defined by the user. The user can quickly and efficiently extract, display, and analyze the data.

Three means of extraction of data are provided: certain short items of information, like social security numbers, can be used to identify each record uniquely for quick access; records can be selected with matching conditions defined by the user; and specific categories of data can be selected. Data can be displayed and analyzed in several ways that include the following: generation of tabular information assembled from comparison of all the records on the system; generation of statistical information on such numerical data as means, standard deviations, and standard errors; and display of formatted lists of output data.

This MIMS program is written in Microsoft FORTRAN 77. It was designed to operate on IBM Personal Computers and compatibles running under PC or MS DOS 2.00 or higher. MIMS was developed in 1987.

This program was written by Sidney Alterescu, Carl A. Friedman, and James W. Frankowski of **Goddard Space Flight Center**. *For further information, Circle 27 on the TSP Request Card.*
GSC-13198

B89-10249

AutoCAD-to-GIFTS Translator Program

Data from drafting programs are used to create finite-element mathematical models.

The AutoCAD-to-GIFTS translator program, ACTOG, was developed to facilitate quick generation of small finite-element models using the CASA/GIFTS finite-element modeling program. ACTOG reads the geometric data of a drawing from the Data Exchange File (DXF) used in AutoCAD and other PC-based drafting programs. The geometric entities recognized by ACTOG include points, lines, arcs, solids, three-dimensional lines, and three-dimensional faces. From this information, ACTOG creates a GIFTS SRC file, which can then be read into the GIFTS preprocessor BULKM or can be modified and read into EDITM to create a finite-element model.

The GIFTS commands created include KPOINT's, SLINE's, CARC's, GRID3's, and GRID4's. The SRC file can be used as is (using the default parameters) or edited for any number of uses. It is assumed that the user has at least a working knowledge of

AutoCAD and GIFTS.

ACTOG was written in Microsoft QuickBasic (Version 2.0). The program was developed for the IBM PC and has been implemented on an IBM PC-compatible computer under DOS 3.21. ACTOG was developed in 1988.

This program was written by Andrew Jones of **Goddard Space Flight Center**. *For further information, Circle 66 on the TSP Request Card.*

GSC-13211

B89-10250

Simulation of Failures and Repairs

Reliability and maintainability of a complicated system can be estimated.

The Automated Reliability/Availability/Maintainability (ARAM) computer program is one of the software tools designed to assess candidate architectures of the data-management system of the Space Station. It evaluates the reliability, availability, and maintainability characteristics of the conceptual system. ARAM uses the data representing the redundancy characteristics of the system (redundancy diagram), the maintainability characteristics of the system, and the reliability parameters of components of the equipment.

"Reliability" as used here means the probability that a function is performed without interruptions within a given time interval. For any unit, the time between failures is assumed to have an exponential probability distribution defined by its mean time between failures. "Maintainability" as used here means the probability that a function is restored within a given time interval. Parameters include repair-service priority, mean time to repair, and availability of spare parts. Maintainability includes such global parameters as the period for replenishment of spare parts and the number of repair technicians.

The ARAM design is based upon the simulation of failures and the possible subsequent repairs of each unit of equipment included in the system. It analyzes the effects of failures and repairs on the system and maintains statistics of the behavior of the system from which the results of the simulation are obtained. During a typical ARAM simulation, when the clock advances to a failure event, the program assesses whether any group fails because of failure of a unit. It then propagates the failure event to all affected groups. Next, ARAM generates a unit-repair event for the repairable unit. Other choices include on-line or off-line backup units. The simulation can be repeated a specified number of times for each one of the seeds specified for the random-number generator, or can be timed. At the end of a simulation, the program computes the average statistics.

ARAM is delivered as a package of files that include the program for the generation of the model and for the simulation, and the template for the data base of the model. A data-base-conversion program enables the users of the previous Version 1.0 to convert their model Version-1.0 data bases to the Version-2.0 format.

ARAM was written for an IBM PC XT/AT or compatible computer. It requires 512K of random-access memory, a hard disk, a printer with 132 columns, and DOS 2.1 or higher. ARAM was developed in 1987.

This program was written by Antonio Vallone and Jack P. Craig of Computer Sciences Corp. for **Langley Research Center**. *For further information, Circle 107 on the TSP Request Card.*

LAR-13997

Mechanics

B8910251

Optical Tracker for Longwall Coal Shearer

A photographic record yields information for correction of the vehicle path.

Marshall Space Flight Center, Alabama

A tracking system records the lateral movements of a longwall coal-shearing vehicle. The system detects the lateral and vertical deviations of the path of the vehicle as it moves along a coal face, shearing coal as it goes. The track on which the vehicle rides can then be adjusted to correct for the deviations so that error does not accumulate in subsequent passes.

A stationary tracking assembly at one end of the coal face transmits a beam of light to a retroreflector on the advancing or receding vehicle. The light reflected back to the source is recorded continuously on

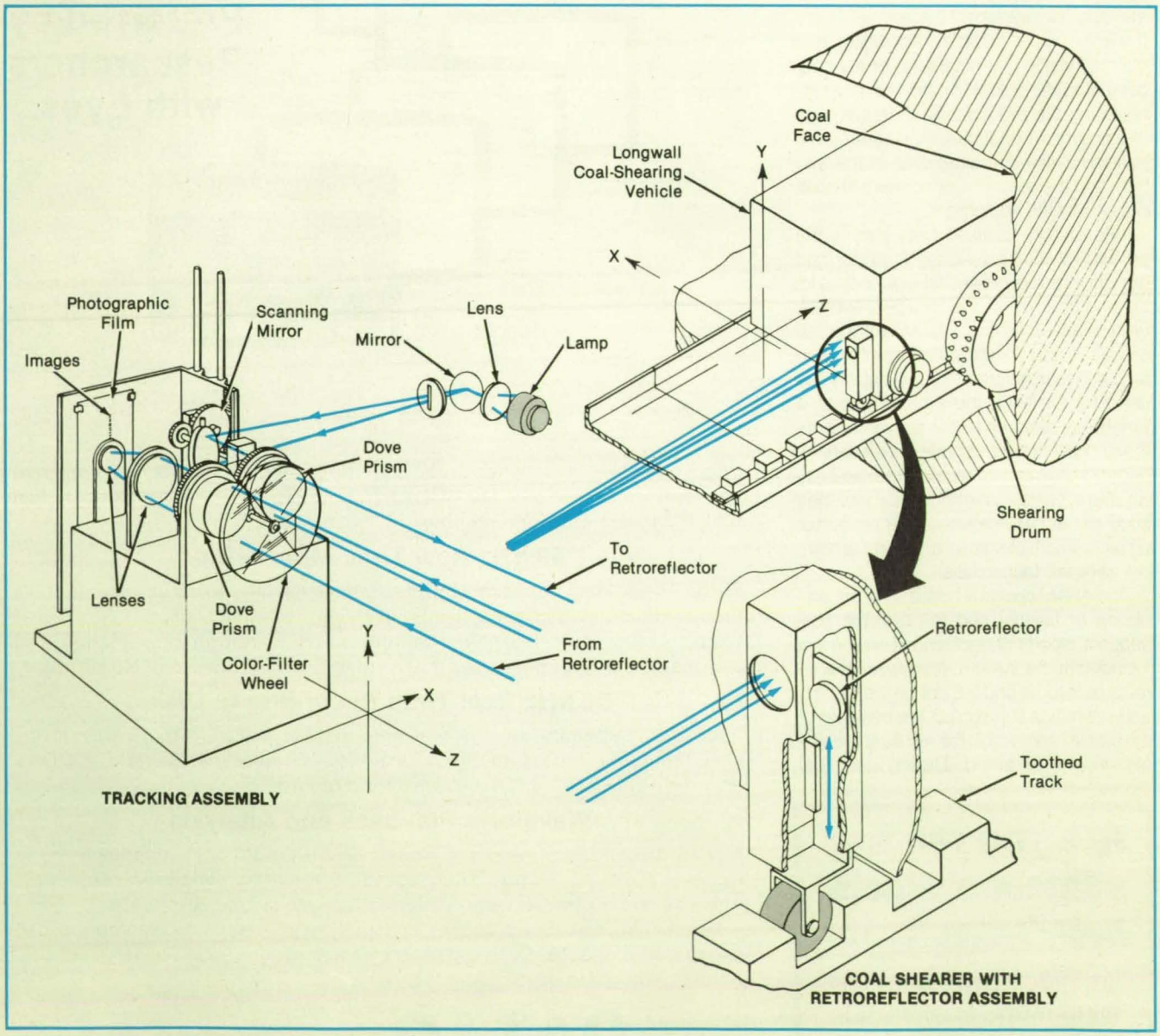

Figure 1. A **Longwall Shearer Rides on Rails** in a mine tunnel, advancing on a toothed track in one of the rails. As the vehicle moves, a retroreflective mirror rides up and down on the teeth, providing a series of pulsed reflections to a film recorder. The recorded positions of the pulses, which have horizontal and vertical orientations, indicate the vertical and horizontal deviations, respectively, of the vehicle.

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film. An overlay placed on the film provides coordinates for determining the deviation of the reflected light beam and, therefore, of the vehicle.

The light source is a mine safety lamp. A lens and aperture in the tracking assembly shape the beam into one with a long, narrow rectangular cross section, and a rotating prism in the housing alternates the orientation of the long rectangular axis between horizontal and vertical. A pivoted mirror scans the beam across the path of the vehicle so that it seeks out the retroreflector.

On the vehicle, the retroreflector rises and falls as it rides on the teeth of the vehicle drive track (see Figure 1). It reflects the beam from the source only in its topmost position and thus provides a series of light pulses to the recording film, each pulse corresponding to a particular tooth in the track. The longitudinal position of the vehicle is thus always known for each pulse.

Since the source housing transmits alternating horizontal and vertical bars of light, the retroreflector returns alternating horizontally- and vertically-oriented pulsed bars of light. The horizontal pulses indicate the vertical position of the vehicle, and the vertical pulses indicate the horizontal position.

In the tracking assembly, a second rotating prism, synchronized with the first, converts the vertical reflected pulses to horizontal, leaving the horizontal reflections unchanged. The reflections are focused into small images of horizontal bars on color photographic film. The film is moved upward as the vehicle advances, so that the sequence of images is a plot of the vertical and lateral deviations as a function of position along the path (see Figure 2). A synchronized rotating color filter gives distinctive colors to the vertical-deviation and horizontal-deviation traces so that they can be distinguished on the color photographic film.

This work was done by Peter D. Poulsen, Richard J. Stein, and Robert E. Pease of **Marshall Space Flight Center**. *For further information, Circle 150 on the TSP Request Card.*

This invention has been patented by NASA (U. S. Patent No. 4,466,667). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 18]. Refer to MFS-25717.

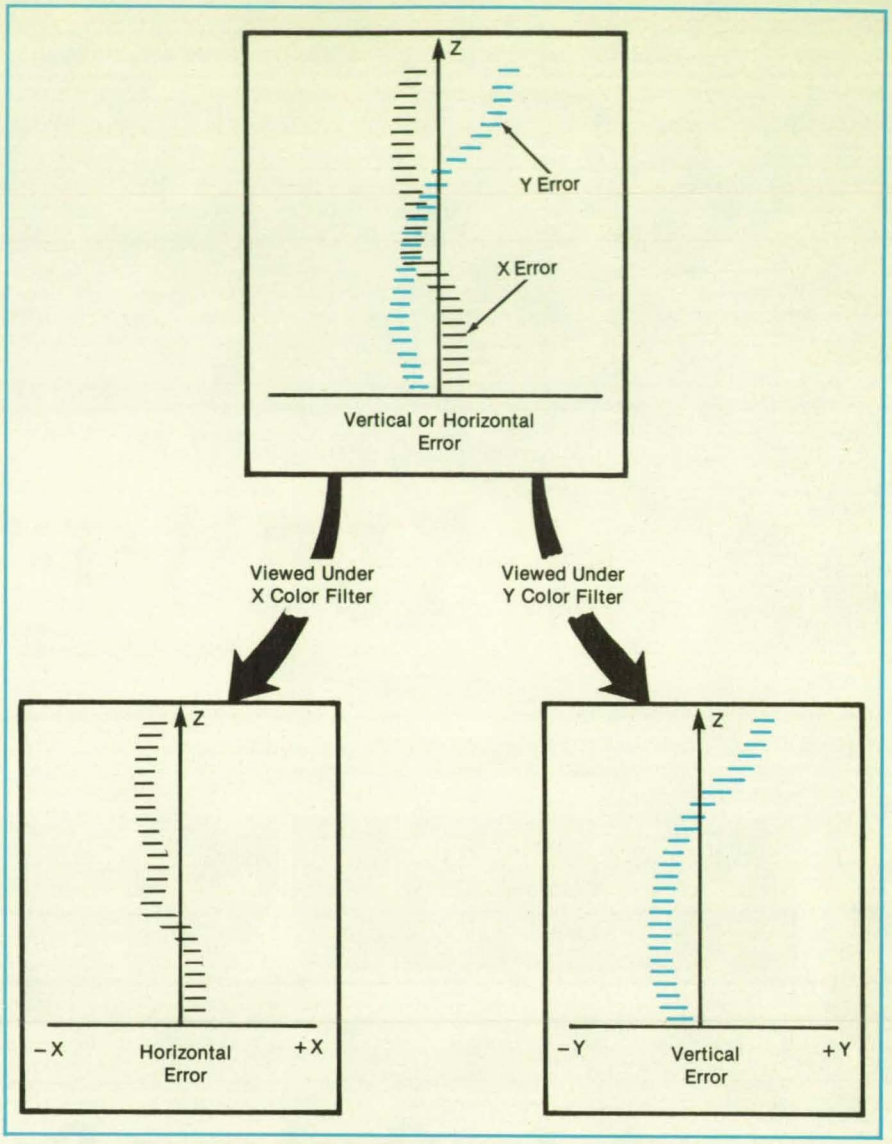


Figure 2. Two **Sequences of Horizontal Lines** on photographic film indicate the path traveled by the longwall shearer. Each sequence has a distinct color to facilitate interpretation of the images: when the film is examined under a suitable color filter, only one sequence is seen at a time.

Effects of Pyrotechnically Generated Shocks

A research program provides better understanding of the pyrotechnic phenomenon for design purposes.

B89-10252

Langley Research Center, Hampton, Virginia

The structural shock waves created on activation of pyrotechnic devices have the potential to damage electronic or other low-mass equipment or to activate equipment sensitive to motion. For example, a pyrotechnically induced activation of the motion-sensitive parachute release system led to the loss of two solid-rocket-booster cases of the Space Shuttle in 1983. There is a lack of information on the pyrotechnically produced loads that can be used by designers. This lack is caused by the complexity of the pulses generated and the difficulty experienced in measurement and analysis.

To evaluate the potential for damage to spacecraft by the activation of pyrotechnic mechanisms, pyrotechnic-shock tests were conducted on three configurations: (1) pin pullers on an orthogonal double Hopkinson bar arrangement, (2) pin pullers on a mockup of the Halogen Occultation Experiment (HALOE) structure, and (3) a section of separation joint on a single Hopkinson bar. Strains and accelerations were measured. The strains were converted to output stresses, forces, and moments. Acceleration shock-response spectra were obtained for both acceleration and force signals.

The devices were attached to the Hopkinson bars with adapters, which are typical of attachments used in practice. To predict the effect of the adapters, finite-element models of the adapter/bar combinations were analyzed; and results were obtained with regard to the grid size, tim

interval, and frequency range required to predict the response to pulses having durations of 10 to 100 μs.

One of the conclusions drawn from this study was that pyrotechnic-shock pulses can contain high-level pulses [thousands of pounds per square inch and thousands of g's acceleration (pressures of the order of tens of megapascals and accelerations of the order of 10^4 m/s^2)], with a high-frequency content up to 50 kHz. Much of the energy content is above 10 kHz. Monitoring methods must be capable of accommodating these levels. The recommended analyses of pyrotechnically generated shocks are spectral analyses, at frequencies up to 50 kHz, of both strain and acceleration histories, maintaining the association of the actual histories with the spectra.

In this study, shock spectra were obtained by a computer program that provides the peak displacement induced in damped, oscillating, spring/mass systems tuned to discrete frequencies from 0 to 50 kHz. It was found that the transmission of pyrotechnically generated shocks into a structure is influenced, as expected, by structural interfaces, materials, and distances between the source and any point on the structure.

The understanding of the pyrotechnic phenomenon has been increased considerably by this study, providing the necessary information not only for comparing various devices but for predicting the responses of structures and evaluating the potential for damage. The results of this research should be useful to designers in making comparison and evaluation tests before committing to costly spacecraft hardware.

This work was done by Laurence J. Bement of **Langley Research Center** *and Maria J. Evans and Vernon H. Neubert of Pennsylvania State University. For further information, Circle 24 on the TSP Request Card.*
LAR-13717

Coolant-Control Valves for Fluid-Sampling Probes

Small built-in leaks prevent overheating. 089-10253

Lewis Research Center, Cleveland, Ohio

In many aeronautical applications, it has been found necessary to sample hot streams of exhaust or other gases where the temperatures of the sample fluids must be controlled within finite limits. In such an application, a steam- or water-cooled gas-sampling probe is inserted into a hot stream of gas to extract a sample. The temperature of the sample is then typically adjusted by adjusting the rate of flow and/or temperature of the coolant (for example, by switching between steam and water).

In a typical installation (see Figure 1), the coolant-fluid control valve is located downstream of the probe to force the flowing coolant to fill the probe and to suppress boiling of the coolant fluid. The temperature of the coolant is monitored at the exit of the probe to couple it closely to the probe.

When a globe valve was used to control the coolant flow, there was a tendency to overheat the probe by inadvertently turning off a flow of coolant in the process of throttling the coolant. This was due to the delay between an adjustment of the valve and the moment when the fluid reached the temperature sensor. This delay increased as the valve was closed, making adjustments difficult at low rates of flow.

To solve this flow-adjustment problem, the downstream flow-control globe valve was replaced with a modified gate valve. The modification consisted of drilling a small hole through the valve gate (see Figure 2), so the valve could never be turned completely off. This "leaky" valve provided

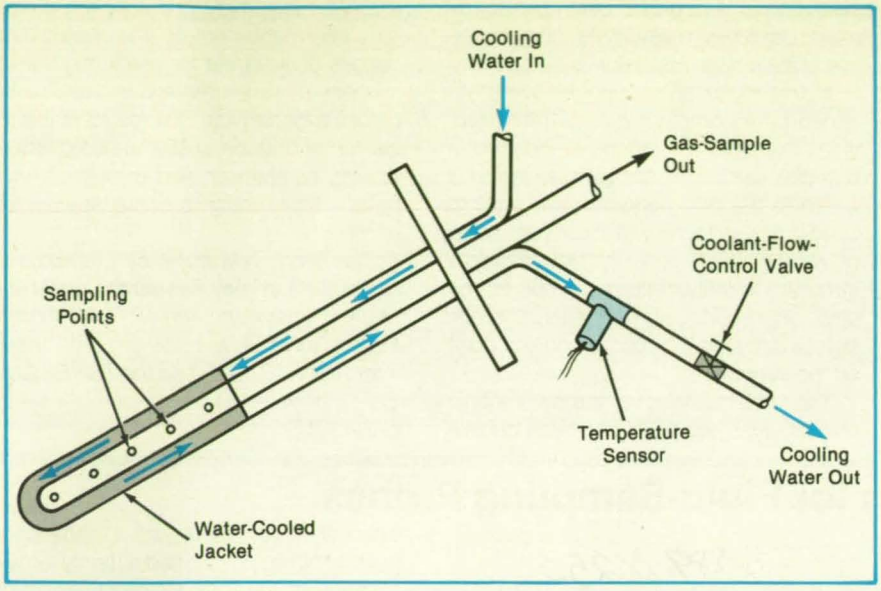
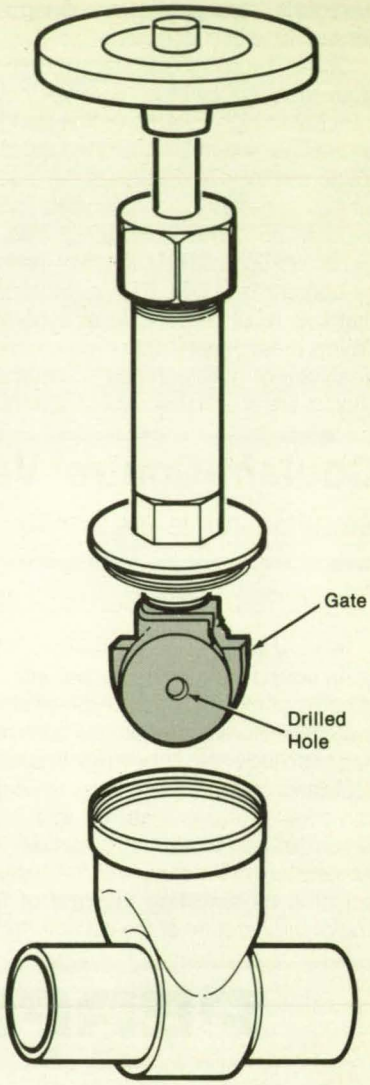


Figure 1. A **Probe Is Cooled** by water. The flow of water is controlled by a valve downstream of the probe to maintain the desired temperature as measured by a sensor downstream of the probe.

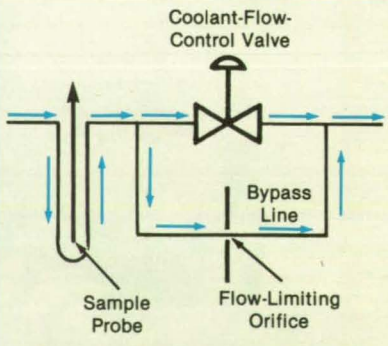
enough flow of coolant to prevent the overheating that could cause the probe to fail.

This work was done by Donald F. Schultz of **Lewis Research Center**. *No further documentation is available.*
LEW-14687



MODIFICATION OF TYPICAL GATE VALVE

Figure 2. A **Built-In Leak** (a drilled hole) assures a minimum flow of coolant to prevent overheating. This principle could also be applied to an automatic control system by installing a small bypass line around the control valve.



SCHEMATIC OF BYPASS LINE FOR AUTOMATIC-CONTROL INSTALLATION

Measuring Tension in a Tether

Tension would be measured at points along the length instead of at the ends.

B89 10254

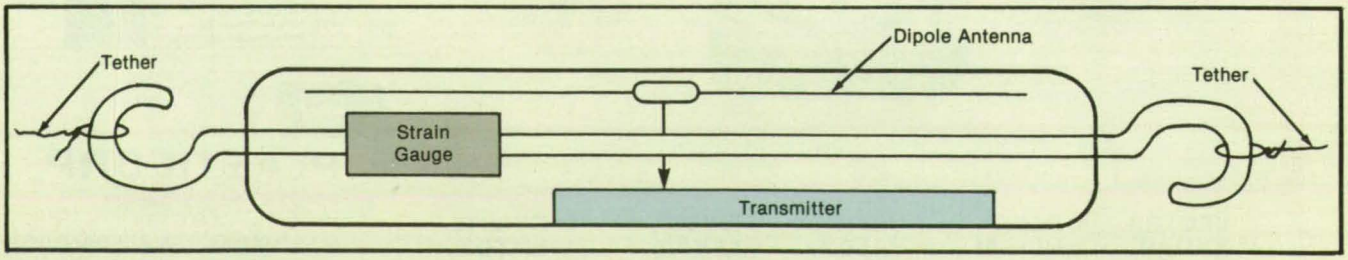
Marshall Space Flight Center, Alabama

A proposed instrument would measure the tension in a tether and transmit data on the tension so that the tension could be monitored or adjusted as necessary. Many such instruments could be positioned along the length of the tether (see figure), unlike currently available devices, which can measure tension only at the ends.

Measurements of the distribution of tension along a tether will enable more-responsive and more-adaptive control. Tension could be adjusted to change the shape of traveling waves on the line, for example. In addition, peak tension could be sensed wherever it occurs. Higher end tension might then be applied, because tension would no longer have to be limited to an arbitrary value to avoid exceeding the maximum allowable tension at an unknown point on the line.

The device would include a strain gauge to sense the tension. The output of the strain gauge could control the modulation of a battery- or solar-powered radio transmitter. In another version, the transmitter could be a "passive nonlinear reflector," which would receive a radio signal on one frequency and return a signal on another frequency with modulation that signifies the tension. In yet another version, data on the tension could be carried on a beam of light. A laser-diode transmitter could be powered by a battery, a radio beam, a beam of light, or solar energy.

This work was done by E. M. Hinman of **Marshall Space Flight Center**. *No further documentation is available.*
MFS-28321



Many **Instrument Capsules** like this one would be placed along a tether to measure the local tension. Each capsule would contain a strain gauge and transmitting electronics.

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

B89-10255

Efficient Computation of Behavior of Aircraft Tires

Simplified mathematical models approximate unsymmetrical responses to loads and environments.

A NASA technical paper discusses the challenging application of computational structural mechanics to the numerical simulation of the responses of aircraft tires during taxiing, takeoff, and landing. An adequate mathematical model must represent the environment to which a tire is subjected and the composite structure of the tire, which includes rubber and textile constituents that exhibit anisotropic, nonhomogeneous properties.

The tires are subjected to inflation pressure and to a variety of unsymmetric mechanical and thermal loads that can result in large structural rotations and deformations as well as in variations in the characteristics of the constituents. Also, the laminated carcass of an aircraft tire is thick enough to allow significant transverse shear deformations, and it may be necessary to use three-dimensional finite elements to model the detailed stress and temperature distributions in certain regions of the tire.

These difficulties can make it prohibitively expensive to simulate numerically the response of a tire. Current tire-modeling studies at NASA Langley Research Center are aimed at developing an accurate and cost-effective computational strategy for predicting the response. This study presents a simple and effective strategy for reducing both the size (that is, the complexity) of the mathematical model of a tire and the cost of analysis of a tire in the presence of symmetry-breaking conditions (unsymmetry in the tire material, shape, or loading). The strategy is based on the approximation of the unsymmetric response of the tire with a linear combination of symmetric and antisymmetric global approximation vectors or modes. The paper demonstrates the effectiveness of the strategy with numerical examples and outlines the potential of the strategy for solving practical tire problems.

The paper presents details of the three main elements of the computational strategy: the use of special three-field, mixed-finite-element models; the use of operator splitting; and the application of a technique that reduces substantially the number of degrees of freedom. The proposed computational strategy is applied to two quasi-symmetric problems: the linear analysis of anisotropic tires through the use of two-dimensional-shell finite elements and the nonlinear analysis of orthotropic tires subjected to unsymmetric loading. Three basic types of symmetry and combinations thereof exhibited by response of the tire are identified.

This work was done by John A. Tanner of **Langley Research Center**, *Ahmed K. Noor of the Joint Institute for Advancement of Flight Sciences, and Carl M. Andersen of the College of William and Mary. Further information may be found in NASA TP-2649 [N87-17690], "Exploiting Symmetries in the Modeling and Analysis of Tires."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LAR-13815

Machinery

Books and Reports

80 Liquid Angular-Momentum Compensator

B89-10256

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Liquid Angular-Momentum Compensator

Flow in a loop supplants the rotation of a heavy, rigid wheel.

A brief report discusses the use of a fluid-loop reaction ring as part of a system that would orient a spacecraft. The proposed device would impart angular rotation to the spacecraft by reacting against a liquid contained in the loop. A pump, or pumps, would provide the impetus to both the spacecraft and the fluid. Hydraulic accumulators and valves could be added to control the flow.

For maximum effect, the flowing (counterrotating) mass should be at the largest feasible diameter, but the operation of the loop would not depend critically upon the precise maintenance of a specified shape. The loop could be made in any of a variety of configurations consistent with the required distribution of mass or effect on angular momentum. For example, without an excessive increase in mass, the loop could be deployed as a ring that surrounds the body, or it could be laid out along a convenient path around the periphery of the body in the plane perpendicular to the angular-momentum axis in question.

This technique offers better control than that of attitude-control thrusters. It also offers several advantages in applications that would otherwise require a large, rigid reaction wheel:

- The fluid loop need occupy only a peripheral circulation path, whereas a rigid reaction wheel would occupy the entire plane of rotation out to its maximum diameter and thus interfere with the mounting of other equipment.
- Unlike a reaction wheel, the fluid loop does not necessarily require a motor sized for maximum torque.
- The fluid loop does not require a large, heavy supporting structure nor a stiff, heavy hub. Thus, the overall mass is reduced, and a greater portion of the overall mass is concentrated in the peripheral circuit.
- The fluid loop does not require difficult-to-make bearings specified to withstand high launch-acceleration loads, provide high stiffness, operate smoothly, and exert minimal frictional torque.

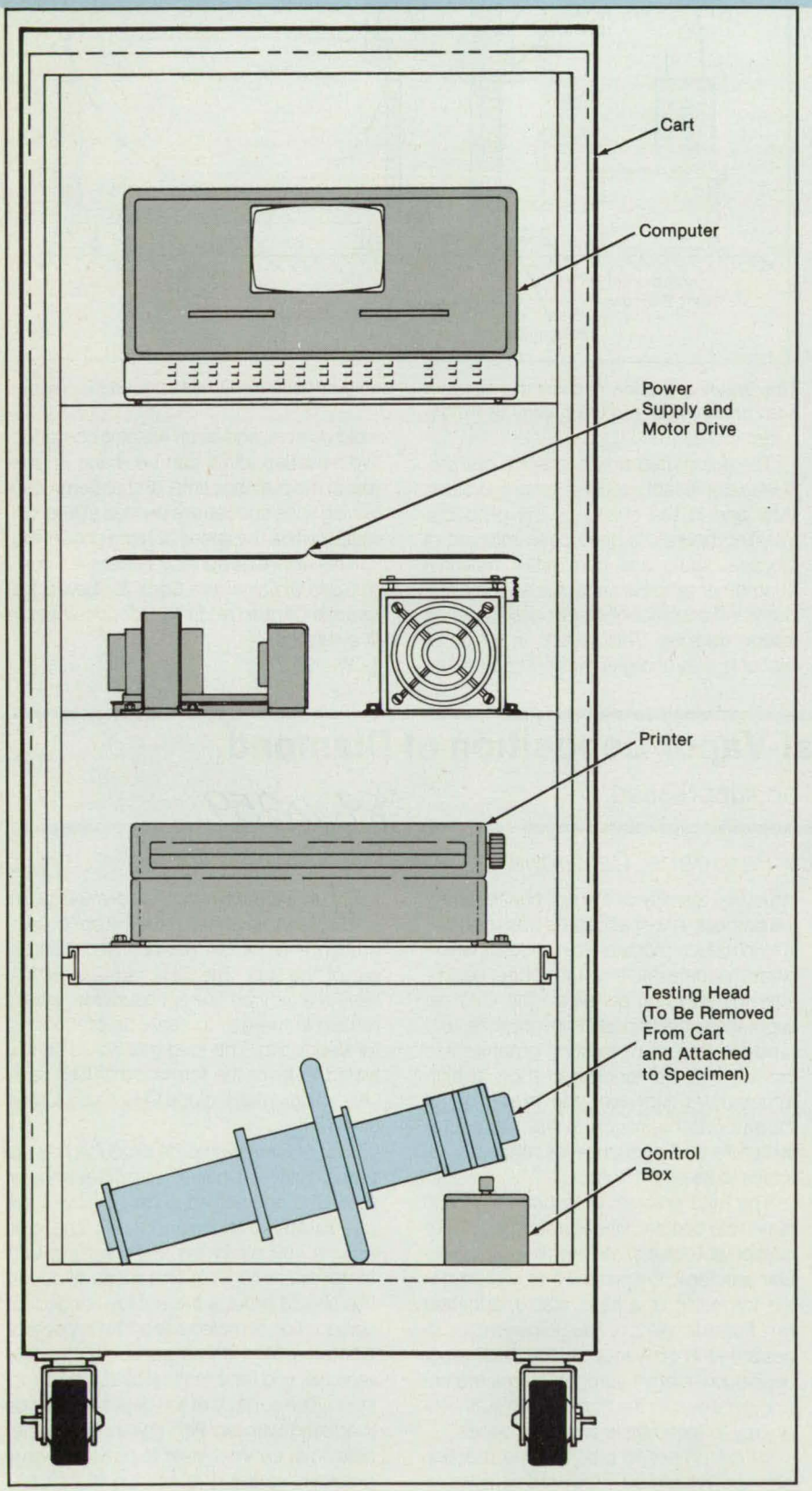
If the fluid has a sufficiently low vapor pressure, it is not necessary to use a strong, heavy tube to contain it. Provided that the fluid is kept relatively free of bubbles and that it is relatively incompressible, its center of mass should not shift appreciably. Thus, unlike a reaction wheel, the fluid loop should not have to be balanced dynamically.

This work was done by Theodore C. Iskenderian of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Fluid-Loop Reaction Ring," Circle 68 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-17204.

Fabrication Technology

Hardware Techniques, and Processes



Portable Pull Tester

Control by a computer ensures field measurements as good as those in a laboratory.

Marshall Space Flight Center, Alabama

NPO-16857

A portable pull tester automatically measures the tensile strengths of test plugs of such materials as ceramics, adhesives, and elastomers at controlled pull rates. Previously, portable testers had uncontrolled pull rates and required manual recording of data; they were subject to considerable error. The new tester produces data of laboratory quality, formerly attainable only with large, immobile equipment.

In the new tester, a dc motor controlled by a personal cornputer drives a lead screw. The lead screw is attached to a load cell and to a test button bonded to a specimen of the material under test. The following data are sampled at a rate of about 1 kHz and fed to the computer:

- The load induced in the specimen, as read from the load cell;
- The strain in the specimen, calculated from the axial motion of the lead screw as inferred from the output of a shaft-angle encoder on the motor; and
- The elapsed time.

These data can be examined on the computer screen, printed out, or transmitted to a larger computer for analysis.

The computer monitors the speed of the motor to maintain it constant, thereby providing a constant rate of pull. This rate can be preset at 0.01 to 0.58 in./min (4.23 to 246 μm/s). A pull force ranging from 0 to 1,000 lb (4,448 N) can be applied. A cart (see figure) holds the computer, printer, and motor-driving circuits so that they can be moved easily to the test site.

This work was done by Harry E. Golden and Henry E. Phillips of Martin Marietta Corp. for **Marshall Space Flight Center**. *For further information, Circle 3 on the TSP Request Card.*
MFS-28302

A **Cart Carries the Equipment** that accompanies the portable pull tester.

Programmable Positioner for Spot Welding

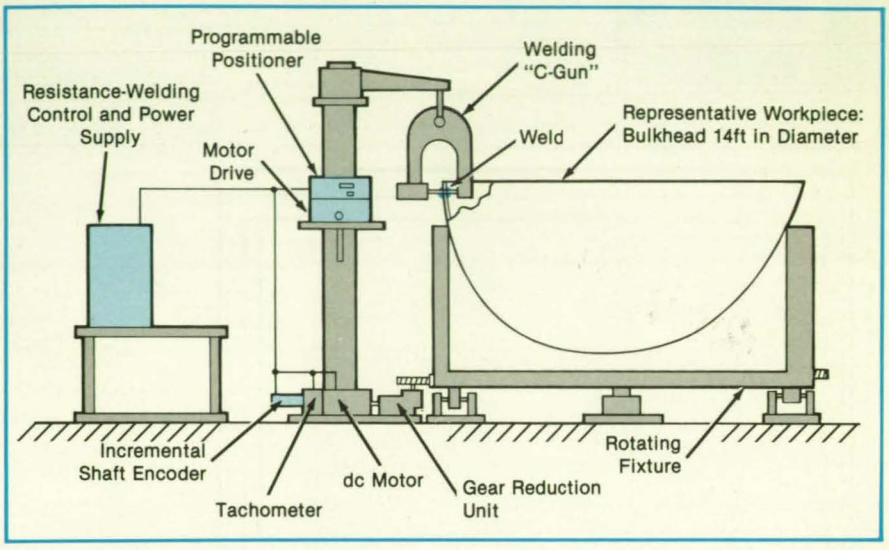
Welds are spaced and performed in sequence automatically.

B89-10258

Lewis Research Center, Cleveland, Ohio

The present method of manufacture of large missile tanks [10 to 14 ft (3 to 4.3 m) in diameter] requires resistance welding of thousands of spot welds on the tank bulkheads. For technical and economical reasons, large aerospace assembly operations are seldom automated, and the consequent manual application of the spot welds is slow and tedious. In addition, errors on the part of operators give rise to mislocated and defective welds.

To improve the fabrication procedure, a welding station was mechanized by installing a preset indexing system and gear drive. The mechanism includes a low-cost, versatile, single-axis motion control and motor drive (see figure) to provide fully-automatic weld sequencing and spot-to-spot spacing. The commercially available controls used in this station were based on a microprocessor and included such features as selectable gain and damping factors, encoder scaling, switch-function inputs and outputs, a motor-drive-signal output, and accommodations for inputs from a tachometer and a position encoder. The interface between the control output and the resistance welder completed the system.



This **Welding Station** relieves the operator of some difficult, tedious tasks and increases both productivity and the quality of welds.

The automated welding station has produced significant improvements in productivity and in the quality of the products. Welding operators have been relieved of physical strain and can better maintain such other process variables as the alignment and condition of electrodes as well as lateral tracking. This results in welds of higher quality and greater accuracy, fewer weld defects, and faster welding operation. Weld-overlap joints can be made in one-fourth the previous time, and patterns containing wide spaces are welded at approximately twice the speed of hand positioning.

This work was done by William A. Roden of General Dynamics Corp. for **Lewis Research Center**. *No further documentation is available.*

LEW-14622

Laser/Plasma/Chemical-Vapor Deposition of Diamond

The deposition of graphite would be suppressed.

B89-10259

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed process for the deposition of diamond films would include a combination of plasma induced in a hydrocarbon feed gas by microwave radiation and irradiation of the plasma and substrate by lasers. At present, the operating conditions for the deposition of diamond films of high quality are unknown, principally because the physical and chemical interactions involved in the process are understood only dimly. Therefore, a program of research and development has also been proposed.

Previous experiments have revealed three major problems in the chemical-vapor deposition of high-quality (preferably single-crystal) diamond films. The first is to avoid the codeposition of other phases — primarily graphite, in which the carbon atoms have the trigonal sp^2 configuration. Graphite hinders the formation of diamond and prematurely terminates the growth of single crystals because diamond requires the tetrahedral sp^3 configuration.

The second problem is to maintain the structural stability of the sp^3 phase during the process. A well-accepted way to do this is to introduce monatomic hydrogen, which binds the metastable sp^3 structure, passivates the dangling bonds on the surface, suppresses the deposition of graphite, and tends to transform existing graphite-rich carbon into diamondlike carbon at high temperature. However, the exact role of monatomic hydrogen in the molecular structure and sequence of reactions remains to be determined.

The third problem is to determine and obtain the directed kinetic, thermal, and excitation energies of the atomic and molecular species in the plasma that will result in the formation of a hard, stable, adherent film. For example, previous experience suggests that in conventional chemical-vapor deposition, many hydrogen atoms are not accelerated into the deposit with sufficient energy to form stable chemical bonds.

In the proposed process, the reaction chamber would be irradiated at a wavelength that would favor the polymerization of CH_2 radicals (which have the sp^2 configuration) into powders that could be filtered out of the gas. The CH_3 radicals, which have the desired sp^3 configuration, would remain in the gas to serve as precursors for deposition. The feed gas would be selected to favor the formation of CH_3 radicals; candidates include CH_4, C_2H_4, C_2H_2, and C_2H_6.

The plasma would be produced by applying sufficient power at a frequency of 2.45 GHz and adjusting the density of the gas to obtain electron kinetic energies around 100 eV in the low-pressure, low-temperature regime. This mode of operation should provide the energy needed for dissociation of molecules by the impacts of electrons, for the transport of fragmented radicals, and for chemical binding in deposition. The surface of the deposit would be irradiated with an ArF (193-nm) or other ultraviolet excimer laser to provide energy precisely where it is needed to facilitate

condensation and the formation of a single crystal.

Research is required to develop the understanding of the chemical-vapor deposition process so that the growth of diamond films can be controlled. A principal issue is the minimization of homogeneous nucleation and maximization of heterogeneous nucleation to maintain the single crystalline structure. Another issue that must be addressed includes the preparation of the substrate and the monatomic-oxygen environment for deposition. It would also be desirable to study the adhesion of films and the variation of their structures and properties (for example, from brittle to flexible and elastomerlike) for use as various kinds of protective and/or lubricating coats.

This work was done by George C. Hsu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 86 on the TSP Request Card.*
NPO-17487

Laser-Assisted Growth of AlGaAs Films

B89-10260

An excimer laser enhances growth by organometallic chemical-vapor deposition.

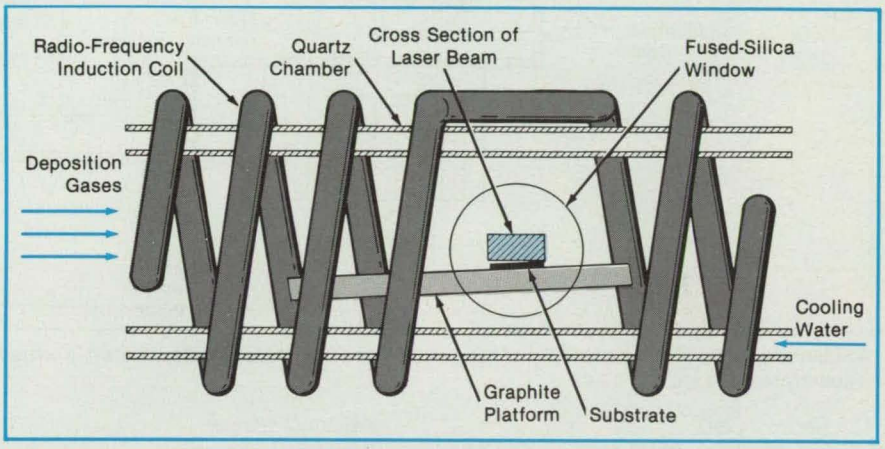
Lewis Research Center, Cleveland, Ohio

Films of aluminum gallium arsenide can be grown on gallium arsenide by laser-assisted organometallic chemical-vapor deposition. The films are single-crystal and contain no detectable oxygen or carbon.

A cleaned substrate of GaAs with (100) orientation is placed in a rf-heated reactor (see figure). A fused-silica window admits light from a KrF excimer laser at a wavelength of 193 nm, which is focused into a beam of 6- by 20-mm cross section and impinges on the substrate at a grazing angle of 15°.

After an initial purge with hydrogen, the temperature is raised to 400 °C, a flow of arsine gas is introduced, and the laser is turned on. The laser is then turned off while flows of trimethyl gallium and trimethyl aluminum are introduced. The laser is then turned on again, and deposition proceeds at a rate of 45 Å/min.

The film grows much more rapidly at 500 °C than at 450 °C. Moreover, a slight amount of interfacial oxygen is detectable in the film deposited at the lower temperature.



A **Laser Beam Impinges on a Substrate** in a quartz reaction chamber surrounded by radio-frequency induction coils.

This work was done by Joseph D. Warner, David M. Wilt, John J. Pouch, and Paul R. Aron of **Lewis Research Center**. *Further information may be found in NASA TM-88937 [N87-23304/NSP], "AlGaAs Growth by OMCVD Using An Excimer Laser."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LEW-14638

Plasma/Neutral-Beam Etching Apparatus

The energies of neutral particles are controllable.

B89-10261

Marshall Space Flight Center, Alabama

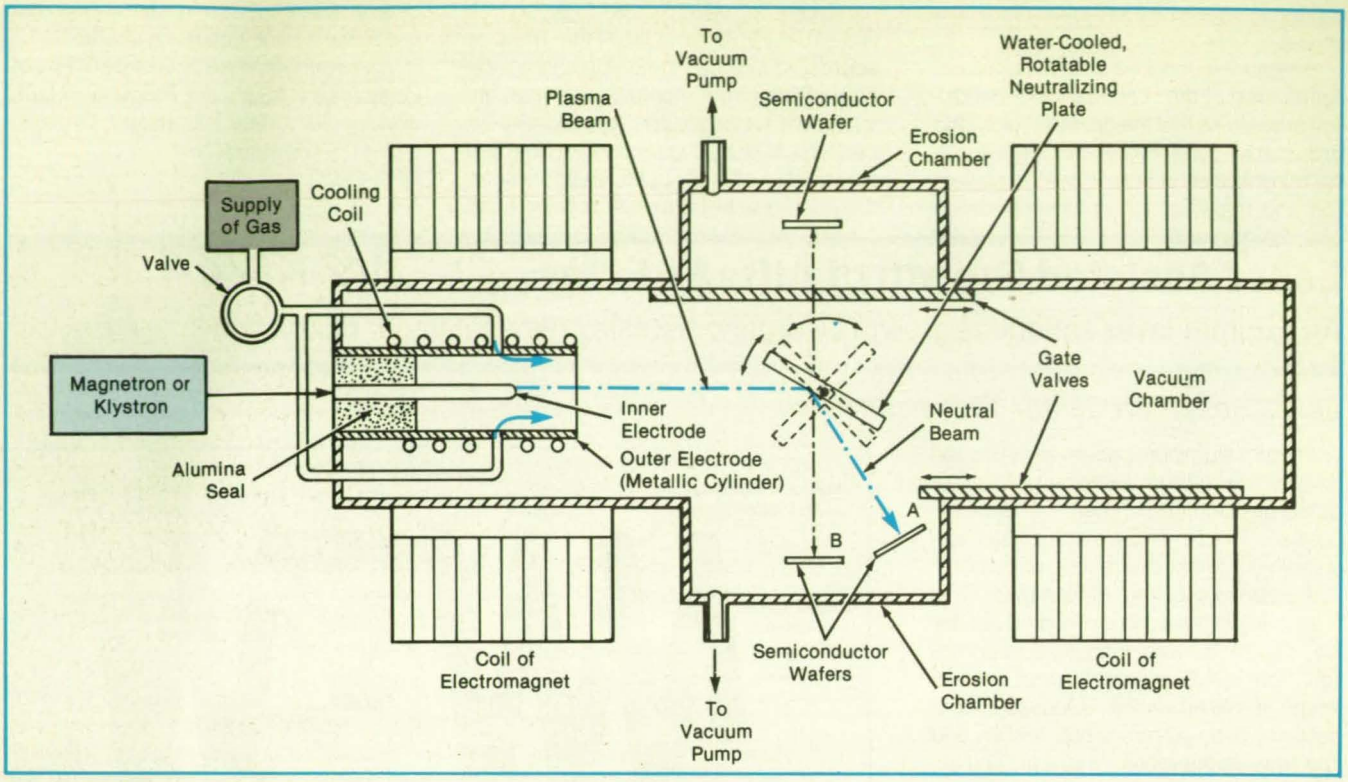
An apparatus has been developed to produce intense beams of reactant atoms for simulating low-Earth-orbit oxygen erosion, for studying beam-gas collisions, and for etching semiconductor substrates. The neutral beam is formed by neutralization and reflection of an accelerated plasma on a metal plate. Initial operation of the device has been very successful in producing continuous and intense ~10-eV atomic oxygen beams, which have been used to etch elemental carbon and polymer layers similar to those used in spacecraft and semiconductor applications. Lattice damage, resulting from electrically charged and/or from high-energy particles, is not caused in this device, because its reactant etchants are low-energy neutral atoms.

The apparatus (see figure) includes a water-cooled coaxial plasma gun and a water-cooled neutralizing plate in a vacuum chamber. Substrates to be eroded or etched can be mounted in either of two erosion chambers, which are side extensions of the main vacuum chamber. Power of 1 to 2 kW at 2.45 GHz is supplied to the inner and outer electrodes of the plasma gun. The reactant gas, typically O_2 in the current device, is supplied to the plasma gun through a piezoelectric valve. The radio-frequency (RF) energy ionizes and heats the gas, producing a 2-cm diameter beam of plasma, of the order of 1 A per kW of RF power.

Electromagnets surrounding the vacuum chamber at both ends produce a magnetic field of 3 kG, which collimates the ions and guides them towards the neutralizing plate. The neutralizing plate is biased to accelerate the ions to energies of 3 to 10 eV. On striking the neutralizer, the ions pick up an electron and reflect from the plate as a neutral beam, which can then be used for erosion or etching. The neutralizing plate may be coated with platinum, gold, or iridium to resist sputtering and chemical erosion.

The constructed device uses 1 kW of power and has produced 1 A of atomic oxygen ions, with a particle density greater than 10^{13}, a duty cycle of 25 percent, and energies up to 30 eV. In the initial tests with this device, 5-μm-thick carbon films and various < 40-μm-thick carbon paints have been eroded after exposure to a 5-eV beam of oxygen with a flux of 10^{15} to 10^{16} O atoms $(cm)^{-2}\,s^{-1}$.

This work was done by William Langer, Samuel Cohen, John Cuthbertson, Dennis Manos, and Robert Motley of Princeton University for **Marshall Space Flight Center**. *For further information, Circle 143 on the*



A **Plasma Is Ejected** from a coaxial plasma gun toward a neutralizing plate, where it is turned into a beam of atoms or molecules and aimed at a substrate to be etched.

TSP Request Card.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

William D. Langer
Princeton University
Plasma Physics Laboratory
James Forrestal Campus
P.O. Box 451
Princeton, NJ 08544

Refer to MFS-26068, volume and number of this NASA Tech Briefs *issue, and the page number.*

Apparatus Impregnates Weak Fibers

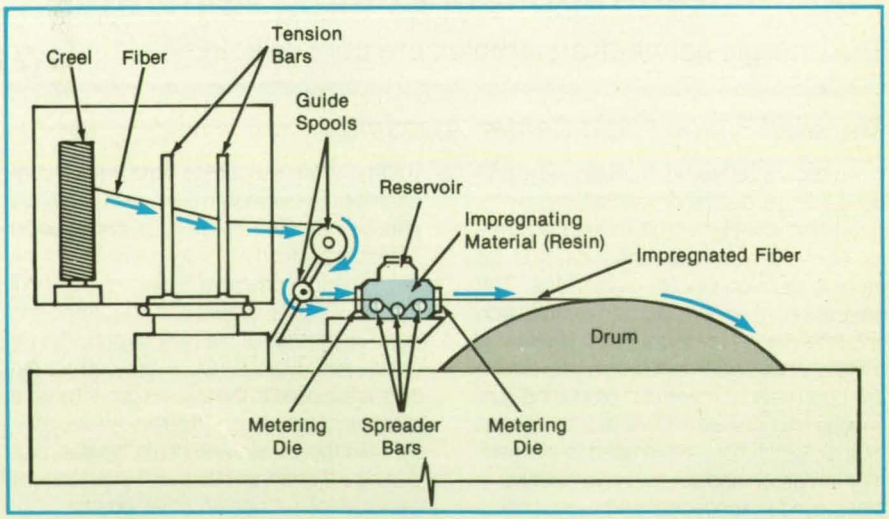
B89-10262

A metering die forces even highly viscous resins and slurries onto weak fibers.

Langley Research Center, Hampton, Virginia

Composite materials made from resin matrices reinforced by fibers have great potential for solving challenging and often critical problems in the design of spacecraft, space structures, and terrestrial structures. To achieve various design goals, it is desirable to have a method of impregnating fibrous material that is capable of using virtually any impregnating material, including resins and slurries of very high viscosity, and nearly all fibrous materials, including those of very low tensile strength.

Resins of high viscosity have posed particular problems in that it is very difficult to fill a fibrous material completely with such a resin, and the resulting air bubbles make the material susceptible to cracking. The use of slurries creates problems because it is difficult to maintain a constant concentration of slurry on a fibrous material, and this leads to inaccurate test data. Similarly, it has been impossible in the past to impregnate fibrous materials fully that have very low tensile strengths because conventional drum winders tend to tear the fibers.



This **Low-Cost Apparatus, Used With a Conventional Drum Winding Machine**, impregnates weak fibrous materials without tearing the fibers.

A low-cost apparatus has been developed for use in a conventional drum winding machine to impregnate fibrous materials that have very low tensile strengths. As shown in the figure, a fiber is fitted onto a freely-spinning unwinding creel. The fiber unwinds from the creel between two tension bars onto guide spools, which align

the fiber so that it can properly enter the sealed reservoir of resin. A stainless-steel metering die at the entrance to the reservoir aligns the fiber and seals the reservoir.

Very beneficial results have been obtained by use of a reservoir made of polyethylene. As the fiber enters the reservoir, it passes through the impregnating material and over polytetrafluoroethylene spreader bars.

The fiber leaves the reservoir through another stainless-steel metering die, which forces the impregnating material and fiber together, meters the amount of impregnating material that goes onto the fiber, and sets the diameter of the resulting impregnated fiber. The impregnated fiber is then wound onto a drum by a conventional winding machine.

Particularly advantageous results have been obtained by use of impregnating materials with very high viscosities, inasmuch as the exit metering die is capable of forcing such impregnating materials into fibers — a capability not available with other methods. Also, the apparatus is capable of using slurries as impregnating materials because the swirling motion created by the movement of fibers over the spreader bars helps to keep the slurries mixed and, consequently, the concentration of the slurry constant. In addition, the simplicity and the proximity of the components of this apparatus make it capable of impregnating fibrous materials that have very low tensile strengths, without tearing the fibers.

This work was done by Clarence E. Stanfield and Maywood L. Wilson of **Langley Research Center**. *For further information, Circle 164 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 18]. Refer to LAR-13603.

Simplified Rotation in Acoustic Levitation

Rotation is controlled with simple, cheap equipment.

B89-10263

NASA's Jet Propulsion Laboratory, Pasadena, California

A simple new technique based on an old discovery can be used to control the orientation of an object levitated acoustically in an axisymmetric (circular cylindrical or spherical) chamber. This method does not require expensive equipment like additional acoustic drivers of precisely adjustable amplitude, phase, and frequency.

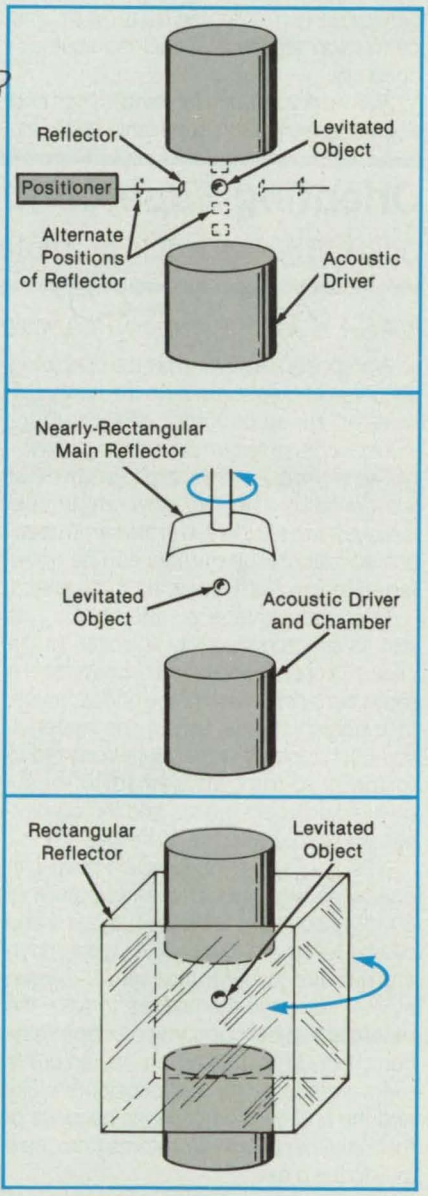
Lord Rayleigh demonstrated that a nonspherical object becomes oriented in a sound field with the axis along which it appears to have the largest cross-sectional area pointing along the direction of propagation of the sound. This principle can be exploited to control the orientation of an object levitated in an axisymmetric sound field by placing in the chamber a sound-reflecting object that is shaped, positioned, and/or oriented to break the symmetry of the field.

The reflecting object acts as a second source of sound. If the reflecting object is large enough, close enough to the levitated object, or focuses the reflected sound sufficiently, the Rayleigh torque exerted on the levitated object by the reflected sound controls the orientation of the object.

The figure shows some of the many possible configurations of orienting reflectors. Different reflectors can be moved in turn into proximity with the levitated object to obtain different orientations. Alternatively, a reflector can be rotated about the axis of the levitator to orient the levitated object along any desired azimuth. The reflector can be turned continuously by a motor to make the levitated object rotate continuously with the reflector about the axis.

This work was done by M. B. Barmatz, M. S. Gaspar, and E. H. Trinh of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 121 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-17086.



Reflectors That Break the Axisymmetry of the acoustic levitator produce Rayleigh torques that orient the levitated object.

Roughening Surfaces of Solar Cells

Bombardment by ions prepares silicon for a roughening etch.

B89-10264

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed treatment that involves bombardment by ions would give silicon solar cells rough surfaces and thus increase the amount of light absorbed by the cells. A smooth cell surface reflects about 30 percent of the incident light, but a textured surface bounces rays from facet to facet, giving them more opportunities to be absorbed and increasing the photovoltaic energy-conversion efficiency (see figure).

Although an antireflection coating also increases the absorption of light, it is optimally matched in only a limited wavelength range unless a graded-refractive-index coating is applied — a difficult and costly procedure. A textured surface, in contrast, increases absorption over the full spectrum of Sunlight.

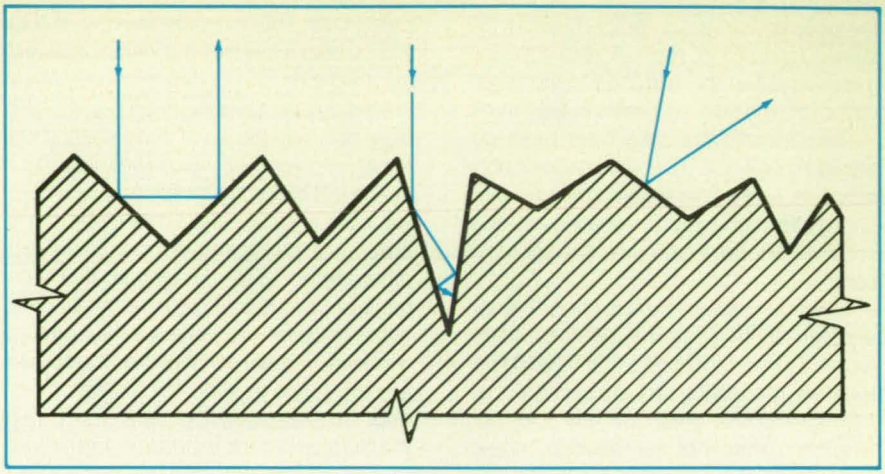
In the first step of the treatment, a wafer of single-crystal silicon would be held at a temperature of 70 °C or higher while it is bombarded with argon or hydrogen ions at kinetic energies between 100 and 2,000 eV. The total dose should be at least 10^{18} ions/cm^2. This high dose would produce a damaged layer on the surface, consisting of an outer polycrystalline sublayer

and an underlying sublayer containing extended defects.

The bombarded wafer would then be etched chemically. The etchant would readily attack the randomly-oriented polycrystalline layer, removing silicon at different speeds depending on the orientations of the crystalline grains. Etchant that penetrates into the extended-defect layer would also remove material at different rates around the defects. The result should be a rough surface.

If hydrogen ions are used in the bombardment, there should be an additional increase in efficiency beyond that due to roughening alone: Implanted hydrogen ions should passivate defects in the bulk silicon. More minority carriers would be generated and collected as a result, and conversion efficiency would increase accordingly.

This work was done by Ranbir Singh and S. J. Fonash of The Pennsylvania State University for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 73 on the TSP Request Card.*
NPO-17295



Photovoltaic Conversion Efficiency Increases with the number of reflections at the surface of a silicon cell because a large part of the light is absorbed at each reflection. A deeply textured surface provides opportunities for multiple reflections.

Orienting Superconductive Crystals for High Current Density

Uniaxial stress would promote rearrangement of oxygen atoms in a favorable direction.

B89-10265

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed technique for the controlled distortion of crystal grains in the newly discovered superconductor $YBa_2Cu_3O_{7-x}$ would increase its current-carrying capacity. The technique would help to ensure that the grains in this and other anisotropic materials are all oriented in the same direction so that charge carriers can be transferred readily from one grain to another.

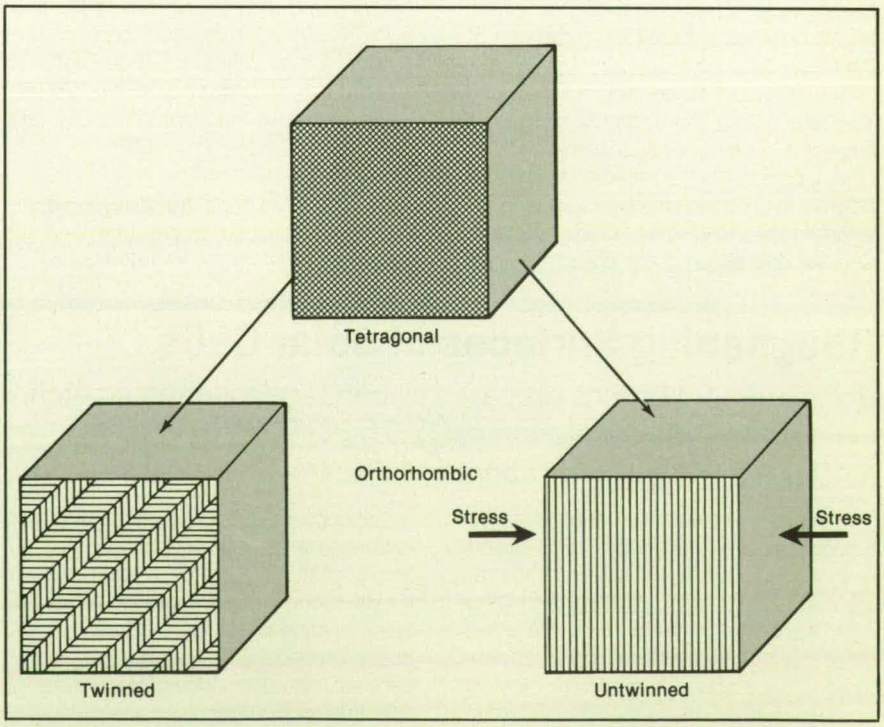
One disadvantage of $YBa_2Cu_3O_{7-x}$ is that its superconductivity is limited to the chains of copper and oxygen atoms that lie along the *b* dimension of the crystal lattice. In a polycrystalline film of the material, superconductivity is therefore confined to tortuous paths between fortuitously oriented adjacent grains, and the current-carrying capacity is therefore low.

$YBa_2Cu_3O_{7-x}$ undergoes a transition in crystalline structure at a temperature of 600 °C. Above this temperature, the *a* and *b* dimensions are identical. As the temperature drops through that value, oxygen atoms rearrange themselves to form the potentially superconductive copper/oxygen chains in the *b* direction. As part of this rearrangement, the *a* dimension shrinks and the *b* dimension expands because of the movement of oxygen atoms from the *a* axis to the *b* axis.

According to the proposed technique, a specimen of $YBa_2Cu_3O_{7-x}$ heated in an oxygen atmosphere would be compressed in one direction as it is slowly cooled below the transition temperature (see figure). Under these conditions, oxygen atoms should tend to rearrange themselves so as to relieve the stress created by the compression. That is, they would tend to form chains with the copper atoms in a direction perpendicular to the direction of compression. Thus, the superconductive *b* axes would all tend to be oriented in the same direction perpendicular to the squeezing direction and would tend to be continuous from one grain to the next.

One technique for compression involves the prior deposition of the $YBa_2Cu_3O_{7-x}$ on a substrate material that has anisotropic contraction. As the substrate is cooled, it contracts more in one direction, thus providing the required uniaxial compression in the material deposited on it. Alternatively, the stress could be induced by mechanically compressing the substrate or by applying an electrostatic field.

This work was done by Paul J. Shlichta of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 97 on the TSP Request Card.*
NPO-17330



Application of Stress to cooled tetragonal $YBa_2Cu_3O_{7-x}$ prevents formation of twins and yields untwinned orthorhombic crystal.

Applying Elastomeric Insulation Inside a Round Case

B89-10266

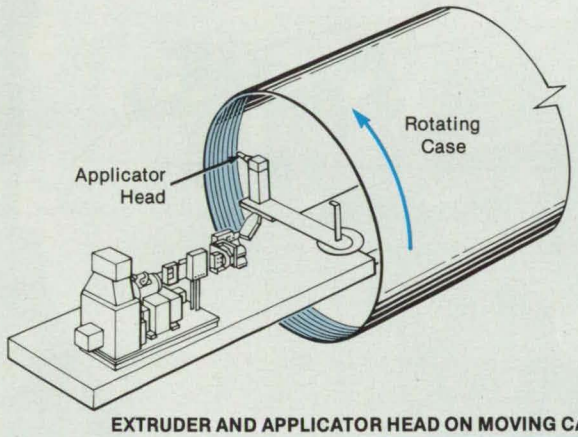
Elastomer is wound onto the inside surface in a continuous strip.

Marshall Space Flight Center, Alabama

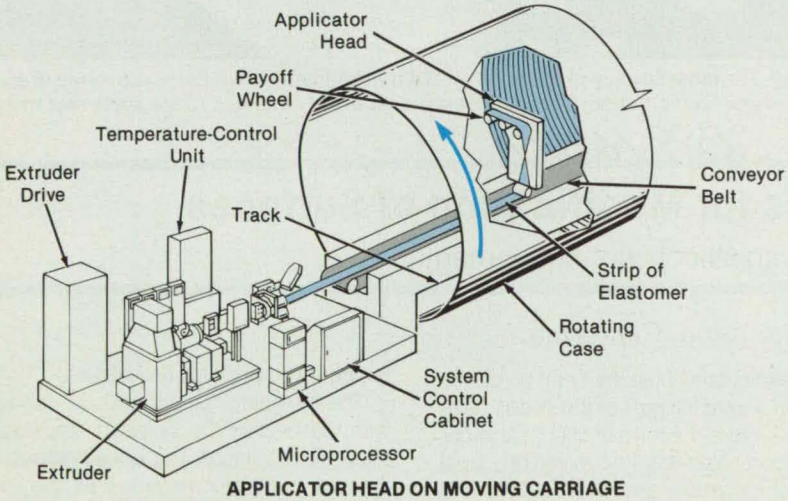
A technique is being developed to apply elastomeric insulation to the inner surfaces of axisymmetric cases. Intended for coating the insides of rocket-motor cases, the technique might also be used to install elastomeric linings in pressure vessels, containers for chemicals, and environmental chambers.

The technique requires the modification of a machine that wraps a strip of elastomer on the outside of a rotating mandrel. The machine extrudes a strip of uncured nitrile rubber, ethylene propylene diene monomer, or other tacky elastomeric resin. The strip is transported to an applicator head, where a payoff wheel rolls the strip onto the surface to be coated.

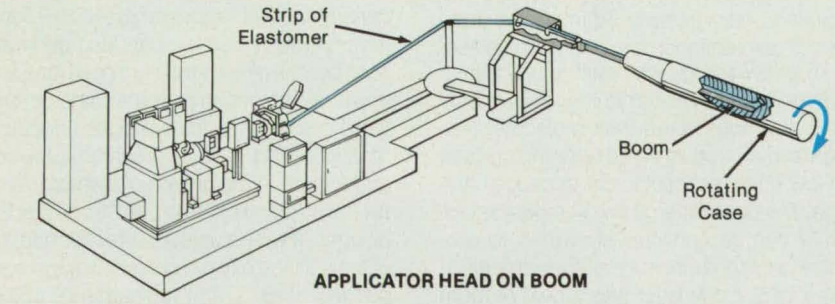
The major modification is required in the strip-delivery system (see Figure 1): The extruder and applicator head could be mount-



EXTRUDER AND APPLICATOR HEAD ON MOVING CARRIAGE



APPLICATOR HEAD ON MOVING CARRIAGE



APPLICATOR HEAD ON BOOM

Figure 1. An **Applicator Head** is moved axially along the inner surface of the rotating case to apply a strip of uncured elastomer.

ed on a carriage that travels along rails inside the case. Alternatively, the applicator head alone could be moved on a track or at the end of a long boom inside the case. In the latter two configurations, the extruder would remain stationary outside the case, and the strip would be transported to the applicator head on rollers or on a conveyor belt.

The payoff wheel can run freely or can be powered to run at a surface speed slightly faster than that of the case, to impart a slight compressive stress to the strip to suppress air pockets and ensure conformity to the inner surface of the case. The axial speed of the applicator head is adjusted so that each turn of the strip partly overlaps the previous turn, in the manner of shingles.

The unmodified machine includes a microprocessor, which controls the speed of extrusion, the rate of rotation of the mandrel (adaptable to control the rate of rotation of the case), the axial speed of the carriage, and the orientation of the applicator head. The microprocessor program is changed to apply the strip to the insides of cylinders or of spherical, semispherical, or conical domed heads (see Figure 2).

Although it will probably be unnecessary in most instances, a tackifier could be applied to the inner surface of the case to hold the uncured strip. A typical tackifier might be a solution of the elastomer in chloroform. The chloroform would evaporate before the lining is cured by heating.

This work was done by Peter G. Russell of Morton Thiokol, Inc., for **Marshall Space Flight Center**. *For further information, Circle 145 on the TSP Request Card.*
MFS-28286

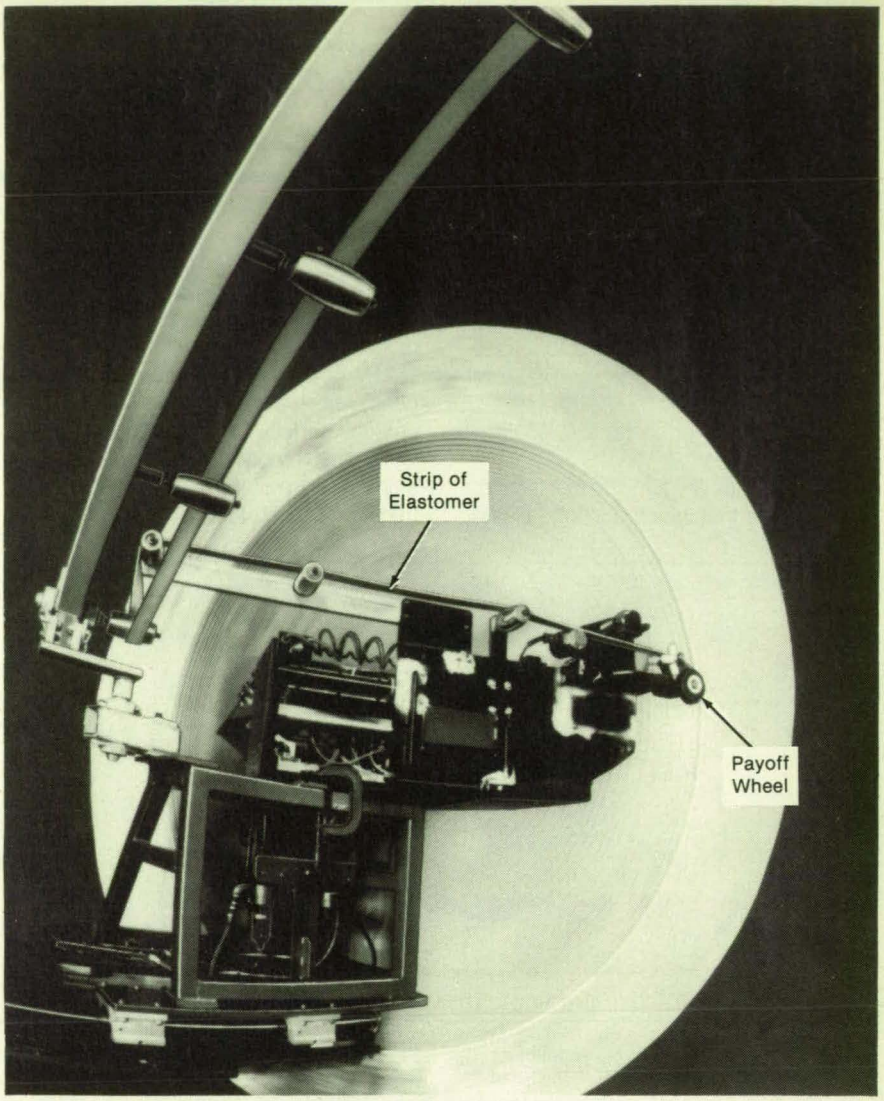


Figure 2. The **Inner Surface of a Dome** 11 ft (3.4 m) in diameter is wrapped with a strip of elastomer. In this configuration, the strip of elastomer is fed on rollers to the applicator head.

B89-10267

Variable-Energy Ion Beams for Modification of Surfaces

Ions at low energy react chemically with silicon without damaging it.

NASA's Jet Propulsion Laboratory, Pasadena, California

A beam of low-energy negative oxygen ions can be used to grow a layer of silicon dioxide on silicon. This beam is unique both in its purity, as it contains no molecular oxygen or other charged species, and in its low energy, which is insufficient to damage the silicon by physically displacing atoms. It promises to be a useful device to study oxidation of semiconductors and, in certain applications, to replace conventional oxidation processes.

The standard method for growing oxides on silicon requires heating the wafer to temperatures of 800 to 1,100°C in a clean quartz furnace filled with flowing gas. This process can cause thermal stress, which can be damaging to high-density integrated circuitry, thin-layered structures, and other delicate devices. Low-temperature alternatives, particularly those that can be directed onto a specific part of the wafer, have been sought in the form of chemical vapor deposition, laser-assisted oxidation, rapid thermal oxidation, anodic oxidation, and ion implantation of oxygen. All of these solutions only partially address the problem of unintentional damage to the device.

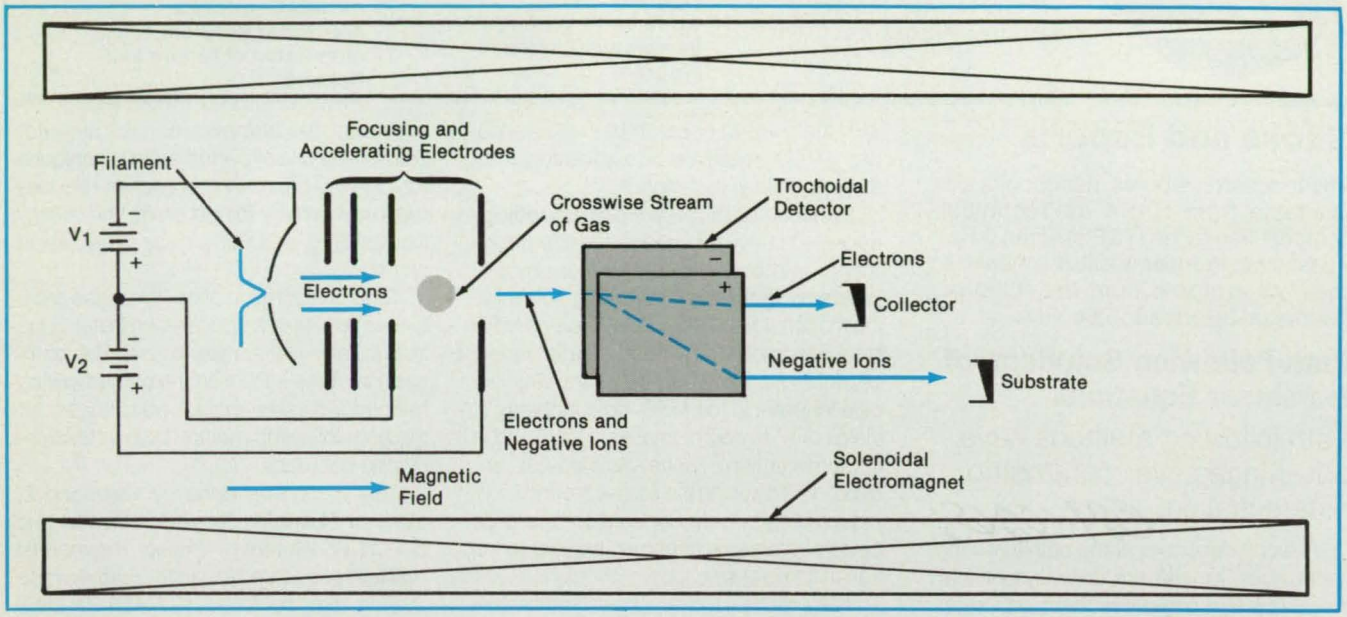
The low-energy ion beam is an optimal growth tool in that atomic oxygen is chemically far more active than molecular oxygen and can be directed onto the surface at low energies insufficient to cause damage. The beam energy and sample temperature can be continuously varied to optimize oxide growth. In initial experiments, a 20-Å thick oxide layer was grown at room temperature in a mattter of minutes, compared to hours or days using other room-temperature oxidizing techniques.

The low-energy growth is accomplished with the help of the ion-beam apparatus shown in the figure. The kinetic energy of the ions in the beam is only 5 eV, the ions are in the ^2P quantum state, and the ion flux density is high, approximately 10^{15} ions/$(cm)^2s$. The apparatus can also generate pure beams of negative hydrogen ions and a variety of negative metal ions. It can therefore be used for hydrogen annealing of silicon and gallium arsenide surfaces and to asist in the growth of diamond films for radiation-resistant semiconductor devices. It will be useful in the modification of the surface oxygen content in superconducting films, in the formation of tunnel junctions, and in the passivation of photosensitive structures such as charge-

coupled devices.

This work was done by Ara Chutjian, Michael H. Hecht, and Otto J. Orient of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 140 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA's Resident Office-JPL [see page 18]. Refer to NPO-17498.



The **Ion-Beam Apparatus** directs electrons into a crosswise stream of gas, thereby generating a stream of negative ions. A pair of charged plates separates the ions from the accompanying electrons and diverts the ion beam to its target — a silicon substrate. The diameter of the beam at the target is 0.5 to 0.75 cm.

Mathematics and Information Sciences

Books and Reports

These reports, studies, handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Path-Following Solutions of Nonlinear Equations

Path-following methods have advantages over parametric differentiation. B89-10268

A report describes some path-following techniques for the solution of nonlinear equations and compares them with other methods. The use of multipurpose techniques that are applicable at more than one stage of a path-following computation results in a system that is relatively simple to understand, program, and use. The comparison of path-following techniques with the method of parametric differentiation (MPD) reveals definite advantages for the path-following methods.

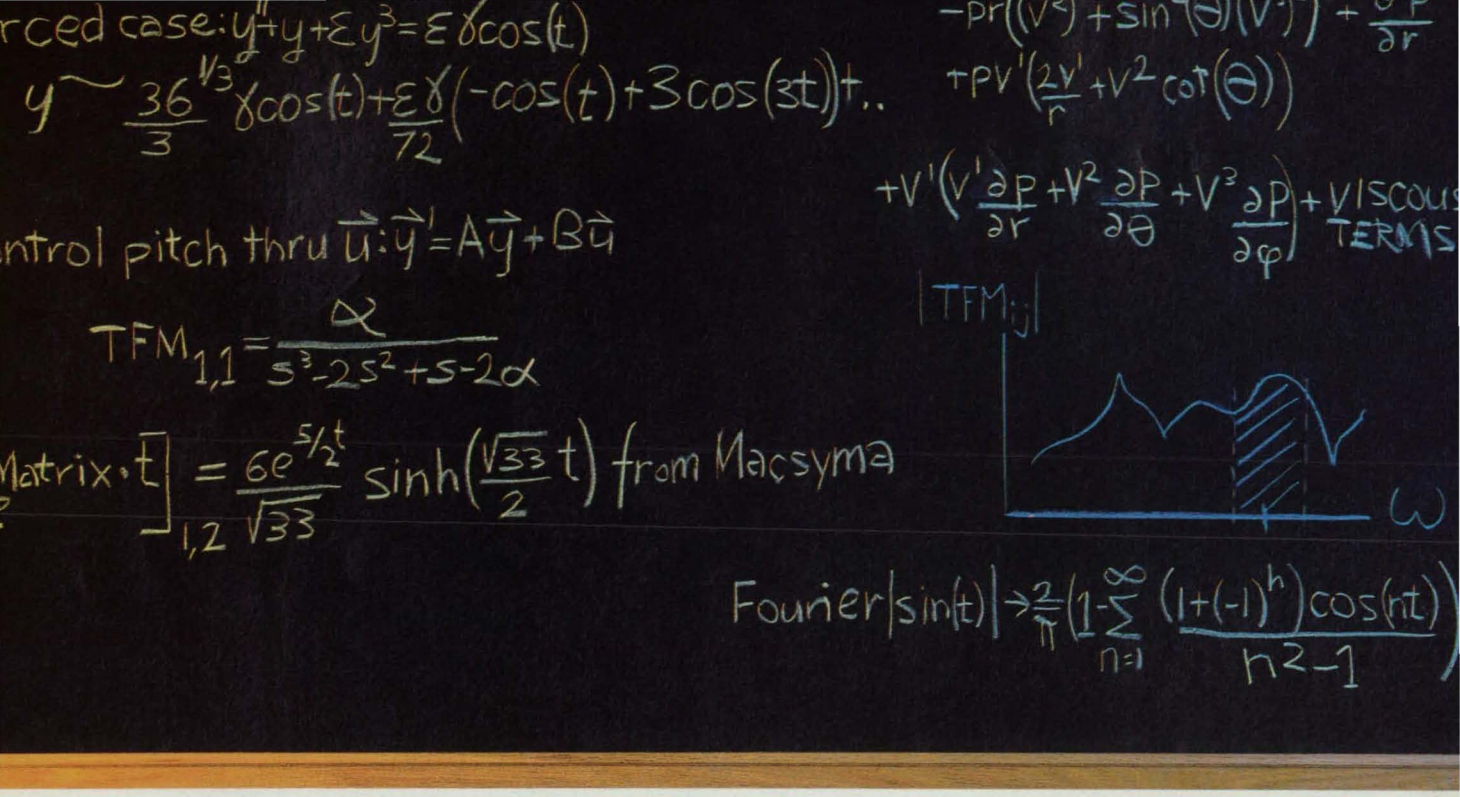
Previous path-following methodology appears to have focused on the bifurcation theory and a restricted class of physical problems that have bifurcating solutions. On the other hand, the closely related MPD has been applied to a much greater variety of problems. However, there are deficiencies inherent in the MPD, both in theory (it yields only an approximate solution) and in implementation. These deficiencies are overcome by using the path-following techniques of this study. Consequently, a large class of problems becomes subject to essentially exact solution.

The emphasis in this investigation has been on multiuse techniques that can be applied at more than one stage of a path-following computation. The use of an extrapolation predictor, for example, eliminates the requirement for solving an operator equation for the predictor solution and provides a means for stepping across singular points. The use of perturbation techniques for locating bifurcating branches reduces the requirement for obtaining the slowly converging solutions near bifurcation points.

This incorporation of multipurpose techniques results in a concise computer code that is relatively simple to use. The comparison of the MPD with the path-following method indicates distinct advantages for the path-following method both in efficiency and accuracy.

This work was done by Raymond L. Barger of **Langley Research Center** *and Robert W. Walters of Virginia Polytechnic Institute and State University. Further information may be found in NASA TP-2654 [N87-14054/NSP], "Some Path-Following Techniques for Solution of Nonlinear Equations and Comparison With Parametric Differentiation."*

Copies may be purchased [prepayment required] from the National Technical In-



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LAR-13750 B89-10269

Noiseless Coding of Magnetometer Signals

Adaptive coding can compress data by factors ranging from 2 to 6.

A report discusses the application of noiseless data-compression coding to the digitized readings of spaceborne magnetometers for transmission back to Earth. The objective of such coding is to increase efficiency by decreasing the rate of transmission without sacrificing the integrity of the data.

The magnetometers, to be flown aboard the Mars Observer and Comet Rendezvous Asteroid Flyby missions, will produce a sequence of measurement vectors at intervals of τ (probably $\gtrsim 0.05$ s). The measurement vector v_i at time t_i will consist of r_i, x_i, y_i, and z_i, where r_i is a β_r-bit number that denotes the dynamic range, and x_i, y_i, and z_i are m-bit representations of the three orthogonal components of the magnetic field put out by a linear quantizer operating in the range r_i. The maximum anticipated values of β_r and m are 3 and 12, respectively. With these parameters, the maximum anticipated rate of transmission would be 780 bits/s, but engineering concerns require a lower rate.

Data-compression coding reduces the rate by using the previous data to predict the subsequent data to the extent possible, thus requiring the transmission of only the difference between the true and anticipated values. Coding is said to be "noiseless" when it introduces no noise; i.e., when the full input data can be recovered from the coded output data. The following noiseless-coding scheme was selected to compress the magnetometer data:

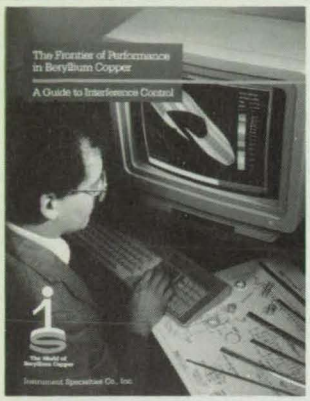
1. Rearrange the data from a sequence of J input vectors into separate sequences of r, x, y, and z values.
2. Process the sequence of J r values into a sequence of variable-length (up to $\beta_r + 1$) subsequences of bits specified by the compression code for r. In a subsequence, a zero in the first bit signals no change, in which case the β_r subsequent bits are not transmitted. A one in the first bit signals a change, in which case the next β_r bits are transmitted to signal the new range.
3. Process the x, y, and z sequences in turn according to a compression code in which the difference between the predicted and the previous value of x, y, or z is mapped into a set of integers.
4. Compress the x, y, and z data further according to a variable-length-code algorithm developed previously.
5. Assemble the data for transmission as the sequence of J coded r values followed by the sequences of x, then y, then z values.
6. Repeat the process for the next sequence of J measurement vectors.

This scheme was implemented with several coding algorithms, which were tested with data from a previous magnetometer experiment of $m = 9$, $\beta_r = 3$, and τ = one-sixth second. While these parameters do not match those of the future magnetometer data, the tests nevertheless indicate trends. Data-transmission rates were reduced by compression factors ranging from slightly less than 2 up to 6. A "breadboard" coder built with an 8086 microprocessor required about 1,000 bytes of memory for instructions and another 1,000 bytes of memory for internal buffers. A breadboard decoder was about half the size of the coder. Both had throughput rates of 20 kb/s — far higher than the rates of the magnetometer data to be processed.

This work was done by Robert F. Rice and Jun-Ji Lee of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Noiseless Coding for the Magnetometer," Circle 32 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL [see page 18]. Refer to NPO-17320.

New Literature

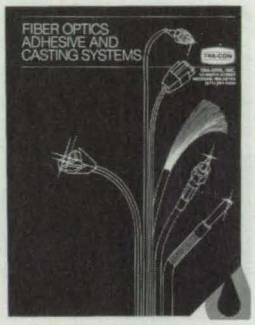


Instrument Specialties Co., Inc. has issued a **guide to help engineers select shielding products** that protect electronic equipment from electromagnetic and radio-frequency interference. The 34-page publication features a color-coded metals compatibility chart to minimize the potential for galvanic corrosion in shielding applications. English and metric specifications for the Pennsylvania-based company's full product line — shielding, electrostatic discharge and grounding products, as well as grounding and shielding contacts — are presented in both tabular and schematic form.
Circle Reader Action Number 716.

The **Magnetic Measurement Handbook** from Dowty RFL Industries Inc., Boonton, NJ, reviews magnetic measurement techniques and terminology and includes in-depth tutorials covering gaussmeter and fluxmeter applications. Available free of charge, the handbook illustrates such applications as measuring magnetic leakage in transformers, testing ferrous powders and slurries, and determining the total flux in U-shaped, C-shaped, and bar magnets.
Circle Reader Action Number 704.

Design Systems Strategies, Scarborough, ME, has released its 1989 **Computer-Aided Design and Drafting (CADD) Buyer's Guide,** featuring more than 80 CADD software products for the A/E design community. Over 400 vendors were surveyed for this year's guide, which covers products that run on nearly 100 platforms and range in price from under $100 up to $100,000.
Circle Reader Action Number 708.

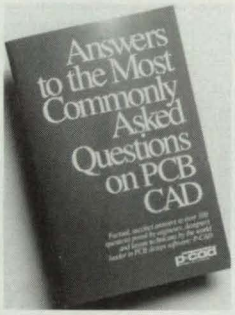
The **Timing Reference Handbook** published by Austron Inc., Austin, TX, contains a history of time measurement, descriptions of the latest technological developments in timing systems, and examples of time and frequency instrument applications. Subjects covered in the 162-page guide include: Time Scales of Measurement; Digital Clock Accuracy and Synchronization; Serial Time Codes; and Time Code Applications.
Circle Reader Action Number 724.



A new line of **epoxy-based adhesives** designed for fiber optics applications is described in a free brochure from Tra-Con Inc., Medford, MA. The formulations can be used for bonding, potting, coating, and terminating applications found in the design, production, assembly, maintenance, and repair of fiber optics products. A detailed chart provides data on color, specific gravity, operating temperature, hardness, spectral transmittance, index of refraction, and impact resistance.
Circle Reader Action Number 722.

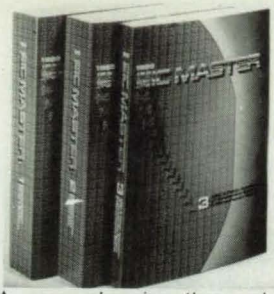
A new brochure from Sabritec, Irvine, CA, spotlights the company's full spectrum of **standard and custom interconnections,** including coax, twinax, multi-pin, hybrid and filter connectors, as well as EMP protection devices, high current bus connectors, and missile umbilical systems. The connectors are also available in complete cable assemblies.
Circle Reader Action Number 718.

Cellmate CM/2, an integrated **hardware/software system designed specifically for testing,** is described in a four-color brochure from the Digalog Corp., Ventura, CA. The unit performs all the tasks of a minicomputer, programmable logic controller, analog to digital front end, frequency counter, data processor, report generator, and many other system elements. It interfaces with hundreds of analog and digital inputs and outputs, strain gauges, thermocouple and RDT inputs, frequency and pulse signals, optically isolated AC/DC switching, and intelligent instruments and controls. The entire system is controlled by a single programming environment, called TOOLBOX, that allows the test developer to create commands to fit the natural language of each industry.
Circle Reader Action Number 720.

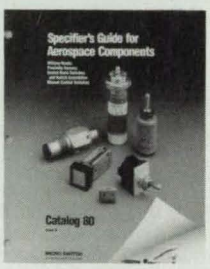


A free booklet distributed by Personal CAD Systems Inc., San Jose, CA, answers 104 frequently asked questions about **printed circuit board CAD.** Compiled from discussions with hundreds of CAD users, the 36-page publication focuses on areas that users have found most confusing in planning their CAD resources. Topics covered include: Advantages of turnkey versus unbundled systems; Pros and cons of various hardware platform configurations; How training requirements affect the CAD investment; Facts about system integration; and Emerging trends in PCB CAD.
Circle Reader Action Number 714.

"Fiber Optic Trends: New Fibers Meet Sensing Demands," a recently published article from Corning Glass Works, Corning, NY, discusses how **interferometric fiber sensors,** used by the military for guidance systems, may prove useful for commercial airlines, automotive navigation systems, and robotic guidance. The author predicts that volume production of specialty fibers by the military will pave the way for commercial applications by reducing manufacturing costs. Offered free of charge, the article describes special requirements associated with sensor use, such as short operating wavelengths, polarization-retaining characteristics, low bending loss, and smaller diameter for higher packing density.
Circle Reader Action Number 726.



A comprehensive three-volume **guide to integrated circuit (IC) design specifications** is now available from Hearst Business Communications Inc., Garden City, NY. Volume One of the IC MASTER describes over 80,000 standard circuits, which are grouped by basic category — Digital, Microprocessor, Linear, Interface, and Memory. Volume Two contains 1200 pages of manufacturers' specifications, and features a directory with addresses and phone numbers for virtually every manufacturer in the IC industry. The third volume is a guide to custom/semicustom ICs and includes gate array, cell-based ASIC, and programmable logic circuits. A Design Auto mation section offers an extensive list of CAE and CAD design tools.
Circle Reader Action Number 710.



The newly revised **Specifier's Guide for Aerospace Components,** published by Honeywell's Micro Switch Division, Freeport, IL, displays a wide array of switches and sensors for harsh environments and military applications. Featured products include solid-state proximity sensors, sealed electromechanical switches, and manual controls such as toggles, rockers, rotary switches, and sealed numeric keyboards. The free guide contains a glossary, military specification data, and details on Micro Switch's custom component capabilities
Circle Reader Action Number 706.

Leybold Vacuum Products Inc., Export, PA, has published a 575-page **product guide and vacuum technology reference manual** featuring vacuum pumps, surface analysis systems and components, vacuum valves, fittings, and accessories. The manual includes product descriptions and photographs, technical data, specifications, and application notes, as well as a list of available articles and a schedule of seminars on vacuum technology.
Circle Reader Action Number 702.

Subject Index

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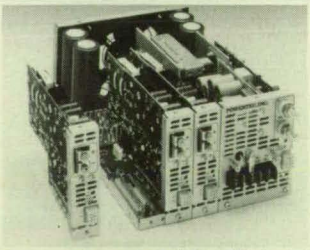
New on the Market

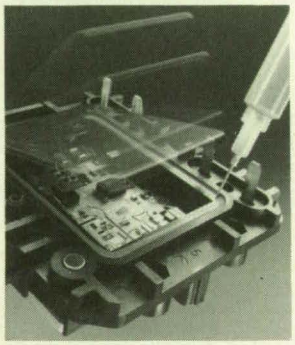
"PC Planning Principles," a **video-based training course** offered by Template Techniques Inc., Spring, TX, teaches how to effectively use project management software. Topics covered on the 68-minute tape include: Critical Path Method; Communicating with Planning Graphics; Project Modeling; Using the Project Model for Decision Making; and Pitfalls to Avoid in the Planning Process. After watching 10 to 15 minutes of the graphics-filled video, the viewer performs an exercise in the workbook, then restarts the tape to view the solution and proceed to the next topic.
Circle Reader Action Number 786.

Film supertwist (FST), a new type of **LCD** that substantially reduces display thickness and weight compared to current technologies, will soon be available from Sharp Electronics Corp., Mahwah, NJ. Combining a layer of organic redardation film with a single layer of supertwisted liquid crystal, the FST LCD panel offers a 30 percent improvement in light transmissivity over the high-resolution double supertwist technology. Sharp's invention will allow for lighter, smaller laptop computers, in which LCD panels have become the display standard.
Circle Reader Action Number 778.



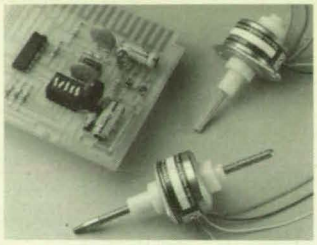
Powertec's new MultiMod™-Series 6 **power supplies** allow the user to choose current/voltage combinations from a large selection of standard switching power packages and DC output modules. Targeted for telecommunications and computer applications, the units can accept up to three auxiliary power supply modules with 2 to 48V outputs, which plug into a 5'' x 8'' x 11'' enclosure containing the main output supply. Main and auxiliary outputs can be directly paralleled and will automatically load share (in proportion to their current ratings). Models rated at 600, 800, 1000, and 1500 watts are now available.
Circle Reader Action Number 788.

INMOS Corp., Colorado Springs, CO, is marketing a new color video controller (CVC) for fast, high-resolution graphics. The IMS G300 CVC is an integrated chip consisting of a color look-up table, a programmable video timing generator, a 32-bit multiplexed pixel port, a triple video DAC with 8-bit resolution, and an on-chip phase-locked loop — all in a single 84-pin grid array or quad cerpac. The device supports all TV timing standards and is capable of interlaced or non-interlaced video. Applications include CAD/CAM, real-time simulation and animation, embedded industrial monitoring, and add-on graphics boards.
Circle Reader Action Number 784.



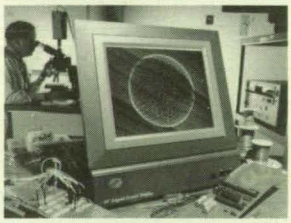
A **new silicone adhesive/sealant** from the Dow Corning Corp., Midland, MI, is tack-free within 40 minutes — five times faster than similar silicone adhesives, according to the manufacturer. Designated X3-6838, the ready-to-use, non-slumping material cures rapidly with unprimed adhesion to most surfaces. It features excellent electrical properties and is suited for sealing wires and electrical connections, control boxes, relays, switches, and printed circuit boards. The experimental product is now available for customer sampling.
Circle Reader Action Number 796.

Shell Chemical Company, Houston, TX, has produced a non-sintering **solid epoxy resin** for electronic applications requiring a low stress cure. The high-purity, low-chlorine material, called Research Resin RSS-1407, creates minimal tensile and compressive stresses upon cure, thereby limiting microcracking of the cured thermoset and damage to the encapsulated device. In addition, the product's extremely low melt viscosity enables its use in applications demanding high filler loadings. The resin can be applied to develop transfer molding compounds, adhesives, and fiber-reinforced laminates, as well as cured coatings for electronic applications such as inks, resists, and lacquers.
Circle Reader Action Number 782.



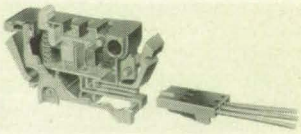
A new **stepper motor control board** from Haydon Switch and Instrument Inc., Waterbury, CT, enables users to activate unipolar stepper motors with just a power supply, or to connect external logic in order to vary motor speed and direction. Furthermore, the board permits testing of an electromechanical project without having to develop a dedicated drive circuit. The printed circuit card is available separately or with a variety of rotary steppers, including rotary and lead screw or captive shaft linear actuators.
Circle Reader Action Number 790.

The first **32-bit language microprocessor,** the SC32™ Language Chip, is now available from Silicon Composers Inc., Palo Alto, CA. Packaged in an 85-pin ceramic pin-grid array, the microprocessor employs a combined stack and register architecture that allows the efficient hardware development and software implementation of high-level programming languages such as Forth, C, and Fortran. The SC32 executes one instruction per clock cycle (10 million instructions per second), and can combine multiple operations into single machine instructions to enable burst-mode speeds as high as 50 million operations per second at 10 MHz.
Circle Reader Action Number 780.



Using the latest thin-film transistor technology, IBM scientists have developed a prototype **color flat-panel display** that is larger and clearer than current commercial models, according to company officials. The 14 inch diagonal panel features a screen density of more than 1.5 million dots and can display up to 16 colors. Images have high contrast and can change on the screen fast enough for animation. Backlit for legibility in bright light, the screen remains visible even from acute angles — an important consideration for laptop/portable and future computer applications in which users will write on desktop panels instead of using a keyboard or mouse.
Circle Reader Action Number 800.

Cambridge Technology Inc., Watertown, MA, has introduced a **portable milli-ohmmeter** designed to measure the resistance of switch and relay contacts, printed circuit board tracks and plated through holes, transformer and motor windings, ground points, connectors, or other low-resistance devices. The lightweight, battery-operated unit offers three automatically selected ranges from 1.999 ohms to 199.9 ohms, 1 milli-ohm resolution, and a basic accuracy of 0.1 percent. Measurements are made using the four-terminal Kelvin technique, which eliminates lead resistance errors.
Circle Reader Action Number 798.



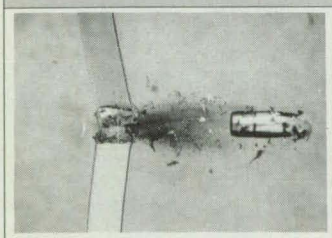
A contactless, **optoelectronic switch** introduced by the Cherry Corp., Waukegan, IL, eliminates the need for snap-action internal metal parts. The solid-state switch employs an infrared emitter and phototransistor sensor combination. An internal "flag" moves in response to pressure on the actuator and interrupts the beam of infrared light from emitter to sensor, thereby changing the switch's output. Cherry engineers estimate the mechanical and electronic life of the new switch to be 50 million cycles. Current markets for this product include office machines, computers, and telecommunications — applications in which dust and vibration threaten the life of traditional snap-action switches.
Circle Reader Action Number 794.

Apple Computer Inc., Cupertino, CA, has introduced the Macintosh® IIcx, a **modular PC** featuring full 32-bit 68030 and 68882 microprocessors, three NuBus™ expansion slots, and Apple's SuperDrive, which allows users to access non-Macintosh disks. Designed for flexibility, the IIcx has a small footprint and can be mounted from the base, side, or with a bracket. Users can disassemble the computer by removing a single screw, making it easy to reach components such as RAM, ROM, and disk drives. The standard IIcx package includes a mouse, System Software 6.0.3, HyperCard®software, documentation, and SuperDrive.
Circle Reader Action Number 792.

New on the Market

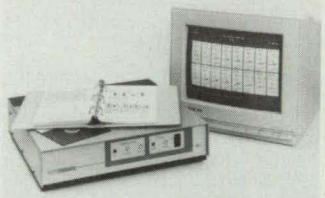
Toyo Corporation's new TPG-4300 **video printer** outputs high-resolution (300 x 300 dpi) color images on A- or B-size paper or transparency film. A built-in intelligent interface eliminates the need to write special software to drive the printer. It adjusts to any CRT monitor, accommodating interlaced or noninterlaced scanning, horizontal scan rates from 15 to 75 KHz, and frame rates from 30 to 80 Hz. Eight program presets for different video timings and specifications permit hardcopy sharing among workstations, PCs, and graphic systems.
Circle Reader Action Number 766.

The Model 2040 laser from Spectra-Physics, Mountain View, CA, offers the highest power available in a commercial **argon ion laser.** The UV-enhanced laser guarantees up to 7 w of mid-UV and 1.5 w deep-UV output, along with 25 w visible power, according to the manufacturer. In addition, the 2040 features a compact power supply and a handheld remote control that provides both analog and digital displays for ease of tuning and peak power readout. Wide bandwidth photodetector electronics deliver stabilized, low-noise light output and accurate power readout from the deep-UV to the near IR.
Circle Reader Action Number 764.



The above image showing a rifle bullet penetrating polycarbonate plastic was captured by a new **CCD still video camera** developed by Hadland Photonics Inc., Cupertino, CA. The Model SV-553 camera produces photographic quality still pictures that can be instantly displayed on monitors or stored on standard VHS videotapes or laser disks. Hard copy prints can be generated with the Polaroid® Model 8801 Printer. The SV-553 also operates as a conventional real-time, continuous-run video camera.
Circle Reader Action Number 760.

An acoustic-based, real-time **weld monitoring system** that nondestructively identifies defects such as cracks and porosity in aluminum, steel, and other materials has been introduced by the Physical Acoustics Corp., Princeton, NJ. Cracks and other flaws form and grow as the weld cools. The expanding flaws emit sounds that are "heard" by piezoelectric sensors mounted along the weld path. As the weld progresses, the acoustic signature is fed through preamps and into the heart of the system — the LOCAN AT acoustic emission instrument. All data is processed through high and low frequency spectra and then stored onto floppy disks. Process information such as alarms and rate-based filters are displayed on a built-in CRT.
Circle Reader Action Number 768.



The ACRO-400E, a high-precision data acquisition and control system from the Acrosystems Corp., Beverly, MA, features 16 differential analog inputs, up to two analog outputs, and 32 digital I/O in a single board-level unit. Suited for distributed applications requiring remote or stand-alone I/O units, the ACRO-400E also includes a built-in microprocessor, 32K bytes of SRAM, 28K points of DRAM, and ACROBASIC, a PROM-resident BASIC language interpreter. Potential uses include on-line statistical process control, energy management, pharmaceutical manufacturing, and materials testing. The unit is priced at $1995.
Circle Reader Action Number 770.

Phase Three Logic Inc., Beaverton, OR, has created CapFast CF/PCB, an **integrated schematic capture and printed circuit board layout package** targeted for PCB design applications. The package includes Phase Three Logic's CF3000 schematic design software and the OEM version of CAD Software's PADS-PCB printed circuit board layout tool. The CF3000 software features schematic and symbol editors; plotting, packaging, and partlist programs; PCB netlist interfaces; a simulation grapher; and the Programmable Netlist Library. Priced at $1995, CapFast CF/PCB runs on the IBM PC/AT, PS/2, and compatibles, with EGA graphics.
Circle Reader Action Number 762.

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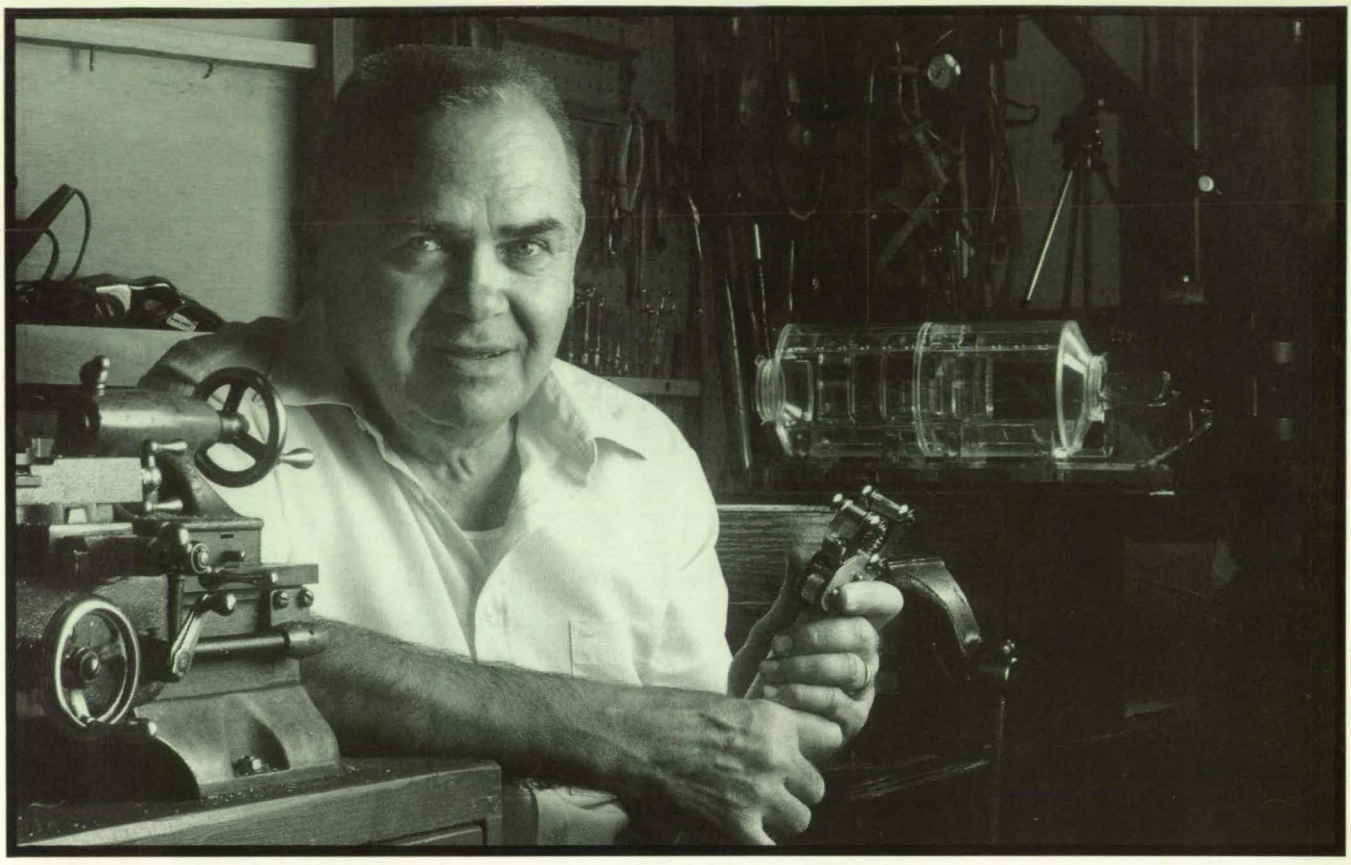

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